THE POSTMORTEM EXAMINATION

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PREFACE

THIS BOOK is intended to make available an orderly presentation of the methods used in the performance of a complete autopsy. It is written in response to a need made evident in the teaching of medical students, young pathologists, and clinical house-officers who are able to spend but a short time in the laboratory before assuming ward duties. The medical student should be encouraged to develop the "autopsy habit" early in his career. The cultivation of this habit throughout his future practice of medicine should furnish him a source of information that will yield an objective evaluation of the accuracy of clinical diagnosis and the efficacy of treatment. Moreover, the practitioner who must on occasion perform an autopsy without expert aid, may find guidance in the chapters which follow. The availability in the English language of a description of methods used both here and abroad, may serve to encourage the performance of autopsies in this country and help in the attainment of greater uniformity and thoroughness.

It is recognized, of course, that the best way to learn autopsy technique is in the autopsy room, under the direction of a skilled pathologist. For the beginner, however, this presentation may serve as an introduction to the actual performance of an autopsy and as a means of shortening the period of ineffective work and distress characteristic of the early days in any new field.

No claim to originality is made for the contents of this book. Most modern autopsy technique is based upon the original methods of either Virchow or Rokitansky. Since no one technique is adequate under all conditions, neither the traditional Virchow method nor the popular Zenker procedure has been followed in full. No attempt has been made to launch a new system of autopsy technique. Every pathologist of experience eventually works out his own variations of the original technique, and for that reason, alternative possibilities have been

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outlined wherever indicated. While due regard has been given methods used in other laboratories, this book is based in large part on procedures found useful in the routine performance of autopsies in the several hospital laboratories under the direction of Professor S. Burt Wolbach. In these laboratories (The Boston Children's Hospital, the Peter Bent Brigham Hospital and the Boston Lying-In Hospital), the dead-house of twenty years ago is no longer apparent. All the virtues of the old autopsy room have been preserved, but the morgue has been replaced by a department of pathology where work is carried on with the cleanliness, efficiency and dignity of a well conducted surgical operating room.

In the preparation of this book I have been aided by a considerable number of persons, to whom I make only general acknowledgments. Specific thanks are due my chief, Dr. S. Burt Wolbach, for advice, stimulation and a critical reading of the manuscript. Dr. Shields Warren has given valuable suggestions regarding the text, and Dr. Irving Akerson expert help in the choice of illustrations. For constant assistance in the preparation of the manuscript I am indebted to my wife. Dr. Charles Ferguson and Dr. Robert Moulton assisted in the correction of the final text. Thanks are due Miss Helen Purtle for her careful typing of the manuscript.

Miss Etta Piotti is responsible for the drawings. In a number of instances, these have been influenced by the illustrations in the books of Nauwerck and of Fischer-Wasels. I am particularly indebted to Professor Fischer-Wasels, whose excellent and well illustrated little book suggested the advisability of a work on autopsy technique in this country. Personal experience in several German laboratories has affected the treatment of the subject. I owe a peculiar debt to the late Carl Benda, who guided my first primary incision.

Finally, it is pleasant to recall with gratitude the stimulating coöperation of Mr. Charles C Thomas.

SIDNEY FARBER

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CHAPTER I

HISTORICAL INTRODUCTION

MODERN medicine properly begins with the institution of systematic autopsies, characterized by thorough examination and objective description. Before the adoption of the complete autopsy, clinical medicine rested upon scattered observations of great merit, obscured in considerable part by hopeless speculation concerning the seat, cause and nature of disease. The autopsy substituted the dead house for the savant's arm chair, as a source of information about disease. By its means, objectivity of thought and method replaced the more comfortable but disastrous practice of building complex classifications of disease from the fertile brain of the non-observing thinker. For a long period in the history of medicine, the autopsy played but an insignificant and intermittent rôle. It was not until after the first half of the nineteenth century that the autopsy assumed its proper position of importance. In the brief biography of the autopsy which follows, we have selected only those episodes which have a definite bearing on the development of technique or on trends of medical thought in relation to the autopsy. For the interested student, numerous reference works and original sources are available.

But little is known of postmortem examinations before the end of the thirteenth century, when, during a plague in Italy in 1286, a physician of Cremona opened many bodies to discover the cause of the pestilence.[1] The plague apparently inspired much of the early interest in the autopsy. In a letter from Avignon concerning the "Black Death" (1347-1350), a cleric of The Netherlands wrote that the opening of bodies had been ordered by the Pope to ascertain the cause of the disease.[2] There is evidence that during the early part of the fourteenth century autopsies were being openly performed in Bologna. An actual report of an examination ordered by the Court in 1302

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to determine whether the deceased had been poisoned, includes the words: "We have assured ourselves of the condition by the evidence of our senses and by the anatomization of the parts." An illustration of a postmortem examination, dated about 1300, and reproduced by Singer[3] from the original in the Bodleian Library, depicts a surgeon opening the body and removing the organs in the presence of a physician and a monk. The primary incision extends from the xiphoid process to the symphysis pubis.

It is of considerable interest that during the early part of the Renaissance, postmortem examinations were performed before anatomic dissection had been instituted. Long explains this presumptive interest in the abnormal by the opinion then prevalent that normal anatomy had been established in the works of Galen.[4] Anatomic dissection had been initiated in southern Italy, and had spread quickly to other parts of the country. It was not until the early part of the fifteenth century that dissections of the human body were made in the Germanic countries. Introduced into Vienna from Italy, the early dissections were conducted under trying conditions, and against considerable opposition.

Until the time of Antonio Benivieni (about 1440-1502), a physician of Florence, autopsies had been performed for medicolegal or religious reasons or to ascertain the cause of epidemics. Benivieni appears to have been the first to request permission from relatives to examine the bodies in obscure cases. A further illustration of this tendency is furnished by Bernard Tornius (about 1452-1497), a physician in Florence. When the son of a high official died, Tornius recommended that an autopsy be performed. His purpose was to discover if the disease was of hereditary character so that he might prescribe more intelligently for the other children in the family.[5]

Contributions to pathologic anatomy in the sixteenth century by means of autopsy and dissection can be found in the works of Vesalius, Eustachius, Paré, and Donatus. A great advance in pathology during this period was made by Schenck von Grafenberg, city physician in Freiburg, who attempted to rid himself

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of the prevalent scholastic influence and to develop observation and investigation. In his seven volume work, he compiled the important medical contributions since Hippocrates and included an account of pathologic observations made by himself and his friends.

Autopsies were performed in the seventeenth century by men such as Malpighi, Glisson, and Sylvius. It was during this period that a pathologic-anatomic museum was built by the Pope's personal physician, Riva (1627-1677), who is credited also with the foundation of a pathologic society in Rome.

Of particular interest to us, is the record of the first postmortem examination conducted by white men in North America.[6] This was performed on July 18, 1533, in the town of Santo Domingo on the island of Español (Haiti and Santo Domingo). Female "Siamese twins," joined together from the umbilical region to a point just below the breasts, had died after eight full days of life. The purpose of the examination was to determine whether there were two souls or one, a matter of grave concern to the officiating clergyman. Master-surgeon Johan Camacho performed the examination, solved the spiritual problem, and ignored the cause of death. Another account of an early autopsy in North America can be found in the record of the second voyage of Jacques Cartier up the St. Lawrence river about 1536.[7] During this expedition his men suffered from scurvy, and in their desperation turned to postmortem examination to find the cause of the strange disease. "That day Philip Rougemont, borne in Amboise, died, being 22 yeeres olde, and because the sicknesse was to us unknowen, our Captaine caused him to be ripped to see if by any meanes possible we might know what it was, and so seeke meanes to save and preserve the rest of the company." There is a record of an autopsy performed in 1639 in Salem, Massachusetts. During the next few decades, a number of examinations were conducted in the United States, mainly for medico-legal reasons.

The eighteenth century witnessed constant advance in pathologic observations. We shall mention only Morgagni (1682-1771), whose great work on the *Seats and Causes of Disease,*

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crowning a long and fruitful life, marked him the founder of pathologic anatomy. The published records of about seven hundred autopsies, performed mainly by himself, are splendid examples of painstaking description, but lack the systematic methods of later workers.

The autopsy, and hence pathologic anatomy, reached its full development in the nineteenth century following a period of rapid progress in the latter part of the eighteenth century. Bichat (1771-1802) who is credited with having made six hundred postmortem examinations in one year, studied tissues in great detail, and observed their qualities after death, their elasticity, and their behavior when treated by heat, acid, and alkalis. His death at thirty-one prevented fulfillment of his promise, but his direct influence on the clinicians Corvisart and Laennec hastened the great French advance in medicine. Corvisart and Laennec regarded the autopsy as a means of studying the development of disease, and used pathologic findings as the basis of physical diagnosis. A word more about Corvisart. Possessed of a clinical perspicacity not then, if now, universal, he put a high value on postmortem examination. When Professor of practical medicine at the Collège de France, he insisted on routine autopsies. As Sigerist has phrased it: "Immense was the delight of the doctor and his pupils if this confirmed the diagnosis. Still more instructive, however, were instances in which discrepancies arose. They gave Corvisart an opportunity of showing in masterly fashion how and why he had erred, and of explaining what was to be learned from these new observations."[8]

Events of comparable importance were taking place in England at this time. A new era in pathology was inaugurated by William Hunter (1718-1783) and John Hunter (1728-1793), with the foundation of the first English museums for the teaching of morbid anatomy. Their contributions were augmented by Mathew Baillie (1761-1823), their nephew, who prepared the first atlas of pathology. Great activity was soon evident in Guy's Hospital, where under the stimulation of Sir Astley Cooper (1768-1841) pathologic investigation began to thrive. Postmortem examinations were performed with more regularity

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than ever before, records were preserved and a museum of morbid anatomy under the direction of a curator was established. The autopsy room here yielded material for the studies of three men whose names have been perpetuated in the nomenclature of pathologic processes: Richard Bright (1789-1859), Thomas Addison (1793-1860) and Thomas Hodgkin (1798-1866). The reputation of this group of English workers was maintained by Samuel Wilks (1824-1911) who carried on as pathologist to Guy's Hospital. As early as 1859, about two hundred and fifty autopsies a year were being performed in the hospital under his direction.

A word about pathology in America during this period. Despite the youth of the country two works on pathologic anatomy appeared. A treatise on pathology was written in 1829 by William Edmonds Horner (1793-1853). This was followed by a text of pathology by Samuel D. Gross (1805-1884) of Philadelphia (Jefferson Medical College), which was published in 1839, and acknowledged the best in the English language at that time. Pathology did not obtain a vigorous hold, however, and it was to Europe that Americans turned for supplementation of their medical education.

Medical progress was catapulted when Rokitansky (1804-1878), in Vienna, and Virchow (1821-1902), in Berlin, brought the autopsy and pathologic anatomy to its modern recognizable state. Rokitansky developed the first complete and systematic method of postmortem examination, and personally performed more than thirty thousand autopsies. With Skoda, he caused Vienna to become the medical center of Europe. Virchow considered him the first true descriptive pathologic anatomist, and regarded the Rokitansky *Hand Book* as the foundation of practical medicine. At the close of his career, Rokitansky stated simply that he had chosen pathologic anatomy as a branch of investigation likely to prove fruitful to clinical medicine. The great fame of the Vienna school attests the wisdom of his choice and the magnitude of his accomplishment.

Virchow is popularly known as the father of pathology. His claim to paternity may be legitimately extended to include

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modern medicine, for during the activity of Virchow, there was hardly a prominent medical worker in the world who had not studied under him, or whose activity had not been deeply affected by his contributions. Some twenty years after he began work in pathology, Virchow stated that his task had been to discredit the speculative humoral pathology and to found in its place a pathology based on natural science. He demonstrated that disease was nothing but a manifestation of a reaction of cells in the human body against causes of disease. He held likewise that every physiologic process possesses an anatomic counter-part, and that disease finds expression in anatomically visible processes.

The unsatisfactory state of the autopsy when Virchow began his work is evident from his writings.[9] Pathologic anatomy was supplementary to the clinic. The clinician decided while the patient was still alive which organ should be the object of investigation. Usually the autopsy was limited to that organ; the rest of the body was neglected or dealt with in a cursory manner. Virchow's comment, "We all know what was the result," needs no amplification. Some clinicians today are unaware that what was an historic propriety in the nineteenth century becomes an anachronism in the twentieth.

Realizing the need for systematic autopsies before order could be brought into medicine, Virchow addressed himself to that task. His problem is stated in the introduction to his book on *Autopsy Technique* (1876), a free translation of which follows: "When I began my appointment in the year 1844, as assistant to Robert Froriep, prosector in the Charité, I found a state of disorder in the autopsy room. There were but few examinations made by the prosector himself and these only on special request: the greatest number were performed by young Charité surgeons, who had no technical training. . . . No notes were made during the autopsy and records were put together after the examination, from memory. . . . My task after I became prosector in 1846, was two-fold. On the one hand I attempted to obtain a useful series of reports by having the autopsies performed by one person and recorded in thorough

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protocols. . . . On the other hand it was necessary to find a systematic method of pathologic anatomic investigation and to introduce a definite technique which could be used as a rule for all ordinary cases. Such a method I have perfected in the course of years. It has been in use long enough to have proved its value."

Virchow's method was designed to permit: (1) a complete appraisal of the extent and nature of alterations in the organs and (2) the possibility of retaining important relationships when necessary, for the purpose of demonstrations. Virchow himself stated that these two conditions opposed each other to some extent, but that a satisfactory solution was found in the use of his method. After careful examination of organs and organ relationships in situ, Virchow removed organs singly and followed this by further section outside the body. Whenever there were found pathologic processes which made it necessary to preserve certain organ relationships, either for further study of the lesion or for purposes of demonstration, the technique was altered. The peritoneal cavity was opened and the contents inspected before the thoracic organs were exposed. This permitted, among other things, a correct measurement of the height of the diaphragm. The brain was sectioned immediately after removal from the skull. The great advantage of the Virchow technique was its simplicity for the beginner. Contrarily, since it permitted organ relationships to be destroyed, it facilitated the occurrence of errors. In the hands of a trained pathologist, the Virchow method undoubtedly constitutes an efficient and expeditious technique. If used with intelligence so that sufficient latitude is permitted in deviations from the standard procedure, it should meet the strictest demands.

The technique of Rokitansky was described by his pupil, Hanns Chiari (1851-1916) in a book published in 1894.[10] The underlying principle of this method was that connections between organs were to be disturbed as little as possible during the autopsy. All organs were examined and opened in situ so that abnormal relations could be discovered and preserved. By this technique examinations were performed in a systematic manner.

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A complete view of pathologic changes was permitted and adequate specimens for demonstrations were obtained.

Heller, a pupil of Friedrich Albert von Zenker (1825-1898) wrote a small outline of autopsy technique in 1902. This was based on the method used by Zenker, first in Dresden, and later in the Pathologic Institute in Erlangen. Zenker had developed independently, and, if influenced by his predecessors, followed Rokitansky and the Viennese school, rather than Virchow. Heller fought against the Virchow technique, which then held sway in most institutes of pathology, and sought to have the Zenker method adopted throughout Germany.[11] His main criticism of the Virchow method was that organ relationships were needlessly destroyed. Heller's insistency upon the preservation of connections between organs led him finally to adopt a method of complete evisceration with later dissection outside the body.

The Zenker method was eventually incorporated in a larger monograph by another pupil of Zenker, Gustave Hauser, who succeeded his master at Erlangen. This was published in 1913 and entitled in memory of Hauser's teacher, *The Zenker Autopsy Technique*.[12] The basic requirement of this method, as defined by Hauser, was that the connections between physiologically related organs must be maintained; separation may occur only when a closer view of pathologic changes is otherwise not possible or found technically too difficult. The organs of the throat and thorax were removed in one piece. The heart was opened by a method which differed considerably from the Virchow technique. The neck and thoracic organs were removed before the peritoneal cavity was opened, as a result of which procedure no measurement of the height of the diaphragm was possible. The intestines were removed with the mesentery, instead of being separated from the mesentery in the body, as in the Virchow method. Numerous other points of difference existed, but they all depended upon the preservation of connections between organs and structures in topographic groups.

With the exception of a number of small changes which can be made without great trouble, both the Rokitansky (Chiari) and the Zenker (Hauser) methods provide adequate means of

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accomplishing the purpose of the autopsy. The main criticism of both methods rests on the necessity for considerable dexterity and experience on the part of the operator. For the beginner, this requirement is of considerable importance since it consumes a longer period of time in the acquisition of proficiency. On the other hand, the retention of connections between related organs prevents the making of serious errors by the young pathologist. From this point of view, the practice of total evisceration advocated by Heller achieves justification. Under conditions of wide-spread disease with involvement of many organs and structures, total evisceration is a procedure of great convenience and value.

Following the lead of Virchow and Rokitansky, other pathologists had taken an interest in autopsy technique. Nauwerck had written his comprehensive manual on postmortem methods in 1891.[13] This was carried through many editions until 1921, and has become a standard work in many countries. Nauwerck stressed the Virchow technique, but included numerous variations and additions which seemed of value to him. A generously illustrated book by Fischer of Frankfurt appeared in 1922.[14] This followed the Virchow tradition and introduced a number of modifications developed by the author. A number of short guides to autopsy technique have appeared in the Germanic countries. The most recent (1932) is a compact manual by Roessle, who leans heavily upon the Zenker procedures, but selects the best features of many methods.[15] Roessle is also responsible for the most complete presentation of the various important postmortem techniques.[16] In France, the method of LeTulle has achieved great popularity (*cf.* LeCount, chapter X). Treatises on the autopsy have appeared in smaller numbers in England and in this country. We shall mention but two large American works: one by Warthin[17] (1897 and 1911) and another by Cattell[18] (1905). Warthin was influenced by Kolisko, but selected, in addition, the best details of the various continental methods. Cattell included detailed directions for the performance of an autopsy in an inclusive book on gross pathology. In England, Shennan's work on post-

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mortem examinations and morbid anatomy is now in its third edition.[19] The standard American book on histological methods by Mallory and Wright[20] contains a concise account of autopsy technique.

For the pathologist not too bound by tradition, familiarity with both the Virchow and the Zenker methods will lead to the proper choice of the best technique or combination of techniques demanded by the special case. It should be understood that a truly complete autopsy in this country is rarely possible by any method. Restrictions which govern the performance of an autopsy, prevent the removal of many structures. The face, the extremities, the eyes, and parts of the mouth, are not often investigated. It is only under unusual circumstances where special facilities are available, as was the case in the Dresden Institute under Schmorl, that structures such as the entire vertebral column may be studied.

Still other considerations enter into a definition of the complete autopsy. The proper selection of material for histologic preparations and the correct preservation of gross specimens for future study and demonstration are problems which perplex every pathologist. How much further than the initial procedures in the autopsy room a pathologist will carry his investigations, depends upon the facilities for histologic and experimental studies afforded by the particular laboratory, and upon the amount of curiosity peculiar to the pathologist himself. For there is no apparent limit to the possibilities embraced in the designation *complete autopsy*. This is evident from the increasing demands upon the pathologist in recent years as a result of the constant advance in all branches of medicine. The autopsy today includes many more procedures than were considered necessary fifty or even twenty years ago. A number of structures in the body have recently taken on new significance, and a greater number of morphologic studies have become necessary. The discovery of the chemical structure of certain vitamins and hormones alone has forced the pathologist to a reconsideration of pathologic sequences and a description of new disease pictures which previously could not be sharply defined.

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What is the present status of pathologic anatomy? Despite important advances in other branches of medicine pathologic anatomy remains the foundation of medical practice and of a good proportion of medical research. Throughout the history of medicine pathologic anatomy maintains a position of *absolute* importance because of the very nature of the field. It can never become obsolete as a means of contribution to medical knowledge as long as there are diseases which are manifested by alterations in the structure of the body. Its *relative* position in the medical world may fluctuate, depending upon the discovery from other sources of new methods of approach. There is no essential antagonism between pathologic anatomy and the fields altered by recent progress in the basic sciences. On the contrary, the pathologist, like the physiologist, has seized such contributions from chemistry and physics as bear upon his work. For the field of pathology includes not merely pathologic anatomy but pathologic physiology and pathologic chemistry as well. And it is the autopsy which furnishes the problems for all three. It should be emphasized that the autopsy has not been completed when the organs have been inspected, removed, and dissected: rather the investigation has just begun. Methods may now be borrowed from any source to assist in the solution of questions raised on gross examination.

What requirements are now imposed upon the pathologist? The definition of Chiari may be enlarged and altered to meet present needs. The pathologist of today must be proficient in the various divisions of anatomy and embryology; he must dedicate years of activity to the routine laboratory in the acquisition of an adequate knowledge of pathologic anatomy; he must recognize problems at the autopsy and investigate them or cause them to be investigated by bacteriologic, physiologic, or chemical means; he must act as guide and as consultant to the clinicians in the solution of their routine problems; he must maintain a broad view over the whole of medicine and keep close connection with progress in the basic sciences and in the clinical fields; he must incorporate into his work new methods developed in other disciplines, and collaborate with the special-

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ist in related lines of endeavor when a combined attack is indicated; he must fulfill the final obligation of spreading by spoken and written word what he has learned through the privilege of his position. First and last, his contributions to the field of pathology must be based upon sound training in the postmortem room. If he is to remain a fruitful worker in his field, he must not stray too far from the source that yields him both his knowledge and his problems.

REFERENCES

1. CHIARI, H.: Geschichte der pathologischen Anatomie des Menschen. In Handbuch der Geschichte der Medizin, T. Puschmann, Jena, 1903.
2. CAMPBELL, A. M.: The Black Death and Men of Learning, New York, Columbia University Press, 1931.
3. SINGER, C.: The Evolution of Anatomy, London, Paul, 1925.
4. LONG, ESMOND R.: A History of Pathology, Baltimore, The Williams and Wilkins Co., 1928.
5. THORNDIKE, LYNN: A Fifteenth Century Autopsy by Bernard Tornius, Ann. M. History, 10:270, 1928.
6. PENA CHAVARRIA, A. and SHIPLEY, P. G.: The Siamese Twins of Española, Ann. M. History, 6:297, 1924.
7. MAJOR, RALPH H.: Classic Descriptions of Disease, Springfield, Ill., Charles C Thomas, 1932 (p. 552).
8. SIGERIST, HENRY E.: The Great Doctors. Translated by Eden and Cedar Paul, New York, W. W. Norton Co., 1933.
9. VIRCHOW, R.: (a) Die Sektions-Technik, second edition, Berlin, August Hirschwald, 1877.

   (b) Postmortem Examinations, Translated from the Fourth German Edition by T. P. Smith, Philadelphia, P. Blakiston's Son & Co., 1885.
10. CHIARI, H.: Pathologisch-Anatomische Sektionstechnik, Berlin, H. Kornfeld, 2 Aufl., 1907.
11. HELLER, A.: Ueber die Notwendigkeit die meist uebliche Sektionstechnik zu aendern, Verhl. d. deutsch. path. Gesell., 6:20, 1903.
12. HAUSER, GUSTAV: Die Zenkersche Sektionstechnik, Jena, G. Fischer, 1913.
13. NAUWERCK, C.: Sektionstechnik, Jena, G. Fischer, Sixth Edition, 1921.
14. FISCHER, BERNHARD: Sektionskurs, Munich, J. F. Bergman, 1922.
15. ROESSLE, ROBERT: Sektionstechnik, Berlin, Julius Springer, 1932.
16. ROESSLE, ROBERT: Technik der Obduktion, etc. in Abderhalden: Handbuch der biologischen Arbeitsmethoden, Section 7, Part 1, Book 6, Page 1093, Berlin, Urban and Schwarzenberg, 1927.
17. WARTHIN, ALFRED SCOTT: Practical Pathology for Students and Physicians. A Manual of Laboratory and Postmortem Technique, Second Edition, Ann Arbor, George Wahr, 1911.
18. CATTELL, HENRY W.: Postmortem Pathology, Second Edition, Philadelphia, J. B. Lippincott Company, 1905.

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19. SHENNAN, THEODORE: Postmortems and Morbid Anatomy, Third Edition, Baltimore, William Wood and Company, 1935.
20. MALLORY and WRIGHT: Pathological Technique, Eighth Edition, Philadelphia and London, W. B. Saunders Company, 1924.

ADDITIONAL READING

FIELD, E.: Praehomerische Sektionen, Muench. med. Wchnschr., **69**:1731, 1922.
GARRISON, FIELDING H.: An Introduction to the History of Medicine, Philadelphia, W. B. Saunders Company, 1929.
HEKTOEN, L.: Early Postmortem Examinations by Europeans in America, J.A.M.A., **82**:949, 1924.
OERTEL, H.: The Past and Present Position of the Autopsy in Medical Education and Practice, J.A.M.A., **60**:1784, 1913.
POSNER, KARL: Rudolf Virchow, Vienna, Rikola Verlag, 1921.
STEINER, W. R.: Some Early Autopsies in the United States, Bull. Johns Hopkins Hosp., **14**:201, 1903.
BEITZKE, HERMANN: Pathologisch-anatomische Diagnostik an der Leiche, Vienna, Julius Springer, 1926.
HALPERT, BELA: Pathologisch-anatomische Sektionsmethode, Vienna, Julius Springer, 1924.
OBERNDORFER, SIEGFRIED: Sektionstechnik, Munich, J. F. Lehman, 1917.

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CHAPTER II

GENERAL CONSIDERATIONS

1. TERMINOLOGY. *Autopsy, necropsy* and *postmortem examination* are used synonymously. Other terms rarely used in this country are *section* (from the commonly used German term *Sektion*) and *necroscopy*. The word *necropsy* (*necros = dead body, corpse + opsy = to view, examine*) has been called the designation of preference. The term *autopsy* (*autos = self + opsy = to view, examine*) has the dignity of common usage and is in more wide-spread favor than any other word. It means literally, to view or examine for oneself and implies a personal examination or inspection. The first use of the word *autopsy* in reference to a postmortem examination has been credited to J. von Ruehl, W. Crighton, and Bluhm in their account published in 1829 of the case of Empress Maria Feodorowna of Russia.[1] A *medicolegal autopsy* differs from the ordinary examination only in the legal use to which the findings are put.

2. PERMISSION FOR POSTMORTEM EXAMINATION.

> Let those who interdict the opening of bodies well understand their errors. When the cause of a disease is obscure, in opposing the dissection of a corpse which must soon become the food of worms, they do no good to the inanimate mass and they cause a grave damage to the rest of mankind; for they prevent the physicians from acquiring a knowledge which may afford the means of a great relief eventually to individuals attacked by a similar disease. No less blame is applicable to those physicians who, from laziness or repugnance, love better to remain in the darkness of ignorance than to scrutinize laboriously the truth, not reflecting that by such conduct they render themselves culpable toward God, themselves and society at large.—DONATUS, 1586.

Before an autopsy is begun, a written permission indicating the extent of the examination should be obtained from the person or agent responsible for the body of the patient. The pathologist

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should be familiar with the laws governing the performance of postmortem examinations in his state and in his hospital (Woodward). It has long been the custom in Germany and Austria to have autopsies performed on most patients who die in hospitals. This achievement has been brought about as a result of education and a liberal interpretation of the law. Virchow and Rokitansky gave much effort to achieve the almost universal autopsy rule in hospitals in their countries. In more recent times Lubarsch, acting as a staunch defender of the autopsy, took so firm a stand that he added much excitement to an already stormy life. Interest in the autopsy developed slowly in America and even today autopsy percentages in hospitals the country over do not compare favorably with those in Germany. During the past twenty-five years many clinicians and pathologists in America have voiced their opinions on this subject. As a result of vigorous endeavor most hospitals connected with medical schools and many located in cities where teaching connections are not available can boast averages far in excess of the fifteen percent demanded for class A rank by the American Medical Association. The situation is far from ideal for the country as a whole. Karsner has estimated that autopsies are performed on less than seven-tenths percent of the dead in the United States,[2] a figure to be compared with a rate of five percent computed by Lubarsch for Germany.[3]

The number of autopsies performed in a given hospital varies with the interest of the clinicians, the effort expended in seeking permission, and the facilities for pathologic work. It has been said that the status of a hospital can be judged with accuracy by the character of its department of pathology. It is of interest that young men seeking interneships have been advised to select a hospital largely on the basis of its autopsy percentage (Christian).[4]

The reasons usually given for refusal of autopsy permission should be known by the doctor, and answers to such objections should form part of his armamentarium.[5, 6] Permission is refused most often on religious or sentimental grounds or because of the opposition of special groups, such as the undertakers. The

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most frequent objections based on religious grounds are given by Jews, who state that their religion prohibits postmortem examination. An opinion obtained by Hammond from Rabbi Levinthal of Philadelphia reads as follows:

> I desire to state that unquestionably the dissection of a corpse is not prohibited when a reputable physician believes that it is essential for advancement of science. Where a postmortem examination may result in the discovery of the origin or cause of some serious disease it is my firm conviction that thus to serve humanity is sanctifying rather than desecrating the body.[7]

The high autopsy percentage in several well known hospitals whose patients are mainly of the Jewish faith demonstrates that there are no serious objections to the performance of autopsies on Jews (Bluestone).

Sentimental objections are more difficult to overcome. If during the last illness of the patient, the doctor has shown expected human sympathy and understanding in addition to his obvious best efforts in the case, sentiment on the part of the relatives can be replaced by an understanding of the value of an autopsy. It is hoped that sentimental objections will give way before the force of education. For the present, the clinician has the greatest influence in the obtaining of permission. He must have an "autopsy conscience," an appreciation of the value of postmortem examinations and a keen understanding of the person petitioned.

Opposition from undertakers can be overcome by coöperation on the part of the pathologist. In New York and Cleveland definite agreements have been drawn up between the pathologists and the undertakers. A copy of the New York agreement is given in Appendix B. Since the main objections of the undertakers have arisen from the condition of the body after autopsy, pathologists may substitute good will for antagonism by meeting their just demands. These will be discussed in detail in the section on reconstruction of the body.

3. THE PURPOSE OF THE AUTOPSY. This subject may be considered in its immediate application to the problem at hand, and in its broader implications. The autopsy begins with a complete examination of all the organs and structures of the body and

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cranial vault, and of as much of the skeleton as may be viewed in the particular case. The immediate purpose of the autopsy is to reveal and demonstrate congenital and acquired abnormalities and gross anatomic changes, to explain mechanical problems and to furnish material for further study by histologic, bacteriologic or chemical methods. A further aim is the determination of the nature of the disease processes and, when possible, the establishment of the cause or mechanism of death. The purpose of the autopsy includes an explanation of clinical signs and symptoms noted during the last illness, and also any deviations from normal during the entire life of the patient. The immediate requirements of the autopsy are not fulfilled until the results of the gross examination and the indicated laboratory studies have been recorded in an accurate and objective manner in permanent form.

Karsner has pointed out that the autopsy includes more than mere "dissection of the dead body for the purpose of ascertaining the cause, seat, or nature of a disease." The broader implications of the purpose of the autopsy lead to a consideration of its relationship to the doctor, the student, the relatives of the deceased, and the State.

The doctor relies upon the autopsy as the means of ascertaining with a greater degree of accuracy than is provided by any other method, the cause of death and the nature of the disease processes from which the patient suffered. He demands complete and objective data so that he may control the accuracy of his diagnosis and have one index of the value of therapeutic procedures employed in a given case. Cabot and Karsner have studied independently the percentage of error in clinical diagnosis and have pointed out clearly the value of the autopsy in this connection.[8, 9] The surgeon finds in the autopsy an opportunity for a study of the results of mechanical operative procedures, and a means of planning new methods which are to be used on future patients. It may be added that the pathologist who is required to give aid to the surgeon in the operating room is dependent upon the autopsy for the accumulation of his knowledge and experience.

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For the medical student, the autopsy provides the first introduction to the abnormal, and the basis for much he will learn throughout his course of study. The arrangement of the modern teaching hospital which permits the student to observe a patient in the ward or operating room and later, if death occurs, in the postmortem room, is one of the finest contributions to the training of the future doctor. The autopsy provides material for the teaching of the medical student, not only in his course in pathology, but also in his clinical years. The clinical teacher has found that the demonstration of a pathologic specimen forms a solid basis for discussion of the clinical manifestations of disease.

The interest of the autopsy to surviving relatives is two-fold. As members of society, they should assist in the accumulation of knowledge which may result in prevention or earlier recognition of disease in other human beings. Such a contribution to the knowledge of the world and to the welfare of mankind is a form of philanthropy not fully appreciated, and yet possible for people of any economic status. Of more immediate interest to the relatives, is the fact that the autopsy yields a more complete explanation than is otherwise possible, of the development of the fatal disease and the cause of death. This may have a direct bearing on the health of other members of the family.

The autopsy furnishes the State with the only reliable source of vital statistics. Since postmortem examinations are performed on less than one percent of the persons who die in the United States, it is apparent that statistics founded mainly on clinical diagnosis must suffer from great inaccuracy. The seriousness of this lack of dependable information, particularly in relation to the incidence of tumors and of certain infectious diseases, has been discussed by a number of workers in the field.[10] The autopsy offers to the State a means of determining the nature of an epidemic or the presence of diseases such as amebic dysentery. With such information public health authorities may handle more efficiently the problems of disease control and prevention. For example, by means of autopsies performed during a recent amebic dysentery outbreak, unsuspected instances

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of the disease were recognized in different parts of the country, and subsequently traced to a common source.

4. SIGNS OF DEATH. Before an autopsy begins, a qualified physician should certify that the patient is dead. A diagnosis of death is made when there is evidence of prolonged cessation of circulation and respiration. The heart usually continues to beat after respiration has ceased. There are two methods for the determination of cessation of circulation. The clinical test made with a stethoscope placed over the heart is adequate. If there is absence of heart sounds during a prolonged examination carried out under suitable conditions, the patient may be pronounced dead. According to the method of Magnus, a ligature is applied to a finger in such a way that the venous channels are compressed without occlusion of the arteries. If circulation has not ceased, the area tested will become engorged with blood. Complete and prolonged absence of respiration is an adequate sign of death. This may be determined by auscultation and by means of the mirror test. A previously chilled mirror is held over the nostrils. If life is still present, warm, moist, exhaled air will condense in visible form on the mirror. Changes brought about after death are found in the eyes. The cornea is insensitive and loses its lustre.

5. POSTMORTEM CHANGES. There are a number of important changes which appear within a few hours after the cessation of circulation and respiration. The following postmortem changes should be sought for and recognized at autopsy: rigor mortis, algor mortis, livor mortis, postmortem clotting of blood, putrefaction and decomposition.

Rigor mortis, or stiffening of the muscles after death, affects first the involuntary muscles, such as the heart. During the first twelve hours after death, rigor involves the voluntary muscles, first of the eyelids and later of the jaw and neck. This is followed by a downward progression over the body. The flexor muscles usually predominate over the extensor group. The muscles of the arms and those of the legs are frequently involved at about the same time.

There is great variability in the time of onset and disappear-

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ance of rigor mortis. The onset of rigor is hastened by heat and retarded by cold. In general, all diseases which lead to excessive metabolism in muscles, with resultant increase in the acidity of muscle fluids, are accompanied by an accelerated onset of rigor. Conditions such as acute fevers, tetanus or strychnine poisoning cause a rapid onset of rigor mortis. Rigor may occur instantaneously in individuals killed suddenly during violent muscular exertion. This fact may have considerable medicolegal importance. When a healthy person meets death by hemorrhage or injury to the brain without previous physical exertion, rigor develops slowly. The body of a decapitated man may remain flaccid for many hours.

The disappearance of rigor proceeds in the order of its onset and varies in time from sixteen to forty-eight hours after death. Once rigor has been broken, it does not recur. Heat hastens, and cold delays the disappearance of rigor. In emaciated individuals who died with fever, rigor disappears more quickly than in muscular persons whose death was caused by accident or hemorrhage. It may be stated in general that the earlier the onset of rigor, the more rapid is its disappearance.

The chemical basis for rigor mortis has been clarified by Fuerth and by Halliburton.[11] Rigor is caused by coagulation of muscle proteins, by a process not identical, however, with the clotting of blood. The proteins concerned in coagulation of muscle have been found to be globulins. Two substances appear to be of importance. Paramyosinogen constitutes about one-fifth and myosinogen the remainder of the total clotting globulin. Both substances are changed into insoluble myosin at low temperatures. An acid reaction is of particular importance in favoring coagulation. Muscle at rest is amphoteric and becomes more and more acid with muscle activity, and when the circulation is shut off. There appears to be no general agreement in reference to the chemical changes concerned with the disappearance of rigor mortis.

Algor mortis or cooling of the body after death, is another postmortem change of importance. It is not a reliable sign of death unless the temperature has fallen fifteen or twenty de-

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grees below the normal level. Premature infants frequently have temperatures of 94°F., and a similar figure has been observed in patients dying of cholera. In general, the dead human body in the nude state loses about 1°F. per hour. There is equalization of the temperature of the interior and exterior of the body in about forty hours. These figures may be altered by a variety of circumstances, so that it is often impossible to determine with accuracy the time of death from the temperature of the body. The body at death may have a temperature as high as 120°F. after death from sunstroke, or as low as 76°F. after long exposure to cold. High body temperature may be maintained or even increased for a short time after death in conditions such as smallpox, cholera and yellow fever, and in certain diseases of the central nervous system. The cooling of the body occurs more rapidly after chronic and wasting diseases, and in old, emaciated individuals. When death occurs suddenly, or after an acute illness, cooling proceeds more slowly. The rate of cooling is affected by external conditions, the temperature of the air or water which may surround the body, the clothing covering the body, and the amount of subcutaneous fat present at the time of death.

Livor mortis or postmortem lividity (also referred to as postmortem hypostasis) occurs almost invariably. Under certain rare conditions it may be absent. Characterized by dark red discoloration of the skin over the dependent parts of the body, it is caused by the sinking of the blood in these parts after death. It is also present as a hyperemic discoloration of the dependent portions of organs such as the lungs, liver, and gastro-intestinal tract. Lividity makes its appearance usually within six to twelve hours after death, although it may occur as early as one hour. It is not present in those portions of the dependent parts of the body where pressure has been applied after death. It is absent, for example, where constricting bands of clothing have caused the capillaries to be emptied of blood and over those parts of the buttocks and shoulders which have come in contact with the morgue slab or table. The skin in areas of livor mortis is not raised, in contrast to the appearance where

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hemorrhage into the tissues has occurred. Lividity may be further differentiated from hemorrhage by means of an incision into a suspected area: blood will escape from the cut vessels if livor mortis is present. Should any doubt exist, the differentiation can be made quite simply by histologic means. When death is caused by suffocation, as in carbon monoxide poisoning, areas of discoloration may appear in the skin over the face.

Closely allied to livor mortis is another postmortem change which is manifested by the appearance of bluish-red streaks in the skin and by the discoloration of blood vessels and the linings of the great vessels and the serous cavities. The discoloration is caused by the diffusion of hemoglobin into the tissues surrounding capillaries and larger vessels after hemoglobin has been liberated by postmortem disintegration of red blood cells. Stains thus caused may enlarge and coalesce to cover large areas of the skin including those areas which are not in dependent parts of the body. Hemolysis and diffusion of hemoglobin occur very quickly when death is caused by infectious diseases, such as hemolytic streptococcus bacteremia or gas bacillus (B. *welchii*) infections. In these diseases, the discoloration may be noticeable shortly after death, particularly in the skin over the face, neck, thorax and abdomen.

Postmortem clotting of blood appears soon after death, especially in the chambers of the heart and in the veins. The rapidity of onset, and the extent of postmortem clotting are often determined by various conditions which obtain just before death. The most extensive clotting of blood is observed after slow death from infectious diseases. When severe anemia has been the cause of death, comparatively little clotting occurs. The blood usually remains fluid after death by poisons such as opium, hydrocyanic acid, phosphorus and phenol. A similar condition is observed after death from asphyxia and from burns. When the patient dies a lingering death, clotting of the blood may begin just after circulation ceases. These formations, known as agonal clots, are not true thrombi. They may consist almost entirely of fibrin in which a few leucocytes may be found, and are caused by the whipping action of the chordae tendineae,

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which separates the fibrin from the other components of the blood just before death.

Postmortem clots are generally of two types. The more common is known as the cruor clot or "currant jelly" clot. Of bright red color and jelly-like consistency, it forms when all the constituents of the blood are coagulated in one mass. The second type, whose color and consistency have given it the name "chicken fat" clot, is found in instances of lingering death, when the action of the heart becomes slowly but increasingly enfeebled. The "chicken fat" clot is formed by the sinking of the red cells. These are of heavier specific gravity than the leucocytes, which remain in the upper part of the clot and accumulate in a yellow translucent mass. The relative position of the two layers in the "chicken fat" clot is a good indication of the position of the body at the time of the formation of the clot. True postmortem clots are not adherent to the heart or vessel wall. Occasionally great experience or histologic examination is needed to differentiate a postmortem clot from a true thrombus.

The color of the blood usually becomes darker just before death because of the reduction of oxyhemoglobin to hemoglobin. The color of the blood as noted at autopsy may yield information about the cause of death. Certain poisons exert a special effect upon hemoglobin. A bright red color is observed after carbon monoxide poisoning and after death from burns or exposure to cold. The blood is dark brown after death from sulphuric acid or phosphorous poisoning, and chocolate brown after death from potassium chlorate.

Putrefaction is caused by the entrance into the organs of the body after death of saprophytic organisms from the intestinal tract. The rapid multiplication of these organisms results in the softening of tissues and the formation of gases, particularly hydrogen sulphide. Since putrefaction is accelerated by warmth and retarded by cold, bodies should be kept in a refrigerator or cold room until the autopsy is performed. Putrefaction is also retarded by the use of embalming substances, such as formalin and arsenic. A green discoloration,

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which may be noted over the abdomen, is formed by the action of hydrogen sulphide on the iron of the blood. Methemoglobin also may be formed by the action of hydrogen sulphide. Gas arising from putrefaction may accumulate in large amounts in the liver, beneath the skin over the face and body, in the serous cavities and in the hollow viscera. The liver may become foamy, and resemble the picture characteristic of gas bacillus infection.

Further postmortem decomposition of the body may be caused without the action of bacteria, by the process of autolysis. The more highly differentiated cells of the parenchymatous organs such as the stomach, liver, pancreas, and kidney undergo autolysis more readily than do cells of the connective tissue elements of the body. Bradley has shown that autolysis or digestion of tissues is brought about by an enzyme or enzymes liberated upon the death of the cell, and operating best in a slightly acid medium.[12] Swelling of organs, as a result of imbibition of water by cells after death, may be noticeable on gross examination. Such swelling may be confused with true cloudy swelling. Postmortem changes may cause softening and even liquefaction of organs. It is of great importance to prevent putrefactive and autolytic changes by proper care of the body after death and by prompt fixation of material for histologic study. The more detailed changes which are associated with putrefaction and exposure of the dead body to the elements for long periods of time are of more concern to the medical examiner than to the routine pathologist. Detailed discussions may be found in treatises on legal medicine.[13]

REFERENCES

1. Foster, F. P.: Medical Dictionary, New York, D. Appleton and Co., 1890.
2. Karsner, H. T.: The Autopsy, J.A.M.A., 88:1367, 1927.
3. Lubarsch, O.: Einiges zur Sterblichkeits und Leichenoeffnungsstatistik, Med. Klin., 20:299, 1924.
4. Christian, H. A.: Selecting a Hospital for an Interneship, J.A.M.A., 86:1499, 1926.
5. Mills, R. G.: Means of Securing Postmortem Examinations, Bull. Am. Coll. Surgeons, 14:40, 1930.

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6. Hoffman, W. J.: Postmortem Examinations: Method of Obtaining Permission. J.A.M.A., 101:1199, 1933.
7. Hammond, F. C.: Overcoming Opposition to Autopsies, Mod. Hosp., 25:333, 1925.
8. Cabot, Richard: Diagnostic Pitfalls Identified during a Study of Three Thousand Autopsies, J.A.M.A., 59:2295, 1912.
9. Karsner, H. T., Rothchild, Leonard, and Crump, E. S.: Clinical Diagnosis as Compared with Necropsy Findings in Six Hundred Cases, J.A.M.A., 73:699, 1919.
10. Wells, H. G.: Relation of Clinical to Necropsy Diagnosis in Cancer and Value of Existing Cancer Statistics, J.A.M.A., 80:737 (March 17) 1923.
11. Halliburton, William D.: Ten Lectures on Biochemistry of Muscle and Nerve, Philadelphia, P. Blakiston's Son & Co., 1904.
12. Bradley, H. C.: Autolysis and Atrophy, Physiol. Reviews, 2:415, 1922.
13. Peterson, F., Haines, W., and Webster, R. W.: Legal Medicine and Toxicology, Second Edition, Philadelphia, W. B. Saunders Co., 1923.

ADDITIONAL READING

Bluestone, E. M.: The Value of Postmortem Examinations and Methods of Obtaining Them, Mod. Hosp., 18:423 (May) 1922.

Gottlieb, J.: Review of Jewish Opinions Regarding Postmortem Examinations, Boston M. & S. J., 196:726, 1927.

Krumbhaar, E. B.: The Need for Postmortem Examinations and Methods of Securing Them, J.A.M.A., 80:1682 (June 9) 1923.

Lewinski-Corwin, E. H.: Statistics of Postmortems in Large Hospitals of the United States and Abroad, J.A.M.A., 60:1787, 1913.

Hektoen, Ludwig: Necropsy Percentage in Relation to Hospital Efficiency, J.A.M.A., 82:949, 1924.

Parkhurst, I. W.: Autopsy Standards: Autopsy Permission, New England J. Med., 203:876, 1930.

Robertson, H. E.: Better Postmortem Service, J. Lab. & Clin. Med. 10:486 (March) 1925; Our Responsibility to Our Deaths, South. M. J., 18:125 (Feb.) 1925.

Spivak, C. D.: Postmortem Examinations Among the Jews, New York M. J., 99:1185, 1914.

Wilson, L. B.: The Necropsy as a Public Service, J.A.M.A., 64:1560 (May 8) 1915.

Wood, F. C.: The Relation of Pathology to Practice, J.A.M.A., 73:569 (Aug. 23) 1919.

Report of the Committee on Postmortem Examinations of the American Hospital Association, 1930, E. M. Bluestone, Chairman.

Woodward, William C.: J.A.M.A., 106:33, 1936. This paper, by the director of the bureau of legal medicine and legislation of The American Medical Association should be consulted for an authoritative opinion on autopsy permission.

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CHAPTER III

EQUIPMENT

1. THE AUTOPSY ROOM. The autopsy room is best located in a part of the hospital somewhat removed from the most traveled routes, yet readily accessible for the transport of bodies by way of tunnels. Large, well lighted, heated and ventilated, it should resemble an efficient operating room in most important details. At all times, the autopsy room should present a clean, orderly and dignified appearance, and so reflect the high purpose to which it is dedicated. Material for the floors and walls should be at once attractive, durable and easy to clean. For floor and wall colors, the most agreeable selection is either white or light green or light blue. The floor may be constructed of cement or tile, or of one of the various types of composition flooring that have recently come into use. Drains conveniently located in the floor facilitate the problem of washing. The walls may be covered by tile for a distance of six feet above the floor, with plaster for the remaining distance to the ceiling.

Light is of great importance. Daylight obtained through large full-paned windows or skylights is to be preferred to even the best forms of artificial lighting. Light from the north is preferable but not essential. For evenings and dark days a number of artificial devices, such as those used in operating rooms, are available. Careful inquiry should be made at various pathologic institutes prior to final selection. Many forms of artificial lighting are accompanied by an objectionable heat that dries the tissues and, equally important, distresses the operator. Yellow light is to be avoided, since it causes distortion of color. Various types of "daylight" lamps are now available. The following convenient arrangement has been designed by Wolbach. A single large dome is suspended by means of a heavy chain from a metal beam which in turn is attached to the ceiling above the autopsy table and which

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extends beyond both ends of the table. Along the under surface of the beam runs a track through which the attachment of the chain may pass. This device permits a shift in the position of the dome along the entire length of the table so that more intense illumination is available where it is needed. Illumination is provided by a one thousand watt lamp enclosed in the metal dome. A blue filter, which forms the bottom of the dome, completely covers the lamp. This device, which gives even, shadowless illumination approximating daylight, has been in successful operation for four years. At the Mallory Institute in Boston, the autopsy tables are lighted by three or five holophane boxes attached to the twelve foot ceiling. Each box contains a one hundred and fifty watt lamp, a reflector and a lens. The illumination thus effected is shadowless light equivalent photometrically to one hundred and fifty foot candles.

The *autopsy table* may be constructed of marble, porcelain, zinc or various types of stainless metal, in one of a number of shapes and designs. There is no general agreement among pathologists in the selection of one particular type of table. The old flat-topped table constructed of porcelain or marble and equipped with a central drain is objectionable because blood and fluid collect on the table and soil the body. The following description is based on the table designed by Wolbach for The Boston Children's Hospital. It was built after careful consideration of the merits and drawbacks noted in tables in use elsewhere. It contains many points of similarity to the excellent table recently described by Warren.[1] The table consists of two main parts, a hollow cast iron base and an upper part constructed entirely of monel metal. This stainless material was selected because it is durable and can be cleansed with ease. For use in a children's hospital measurements of sixty-two by thirty inches suffice; in an adult hospital, eighty-four by thirty inches. The upper part of the table consists of a top and sloping funnel-shaped sides carried down to a central drain. The drain pipe has a diameter of three inches. Its mouth is covered by a fine-meshed screen.

All plumbing is contained within the hollow cast iron base.

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No overhead pipes are used. A single pipe, projecting through the central drain for a distance of six inches, is connected by means of a flexible rubber tube with a single faucet placed in the sponge basin. The pipe carries both hot and cold water which can be controlled by small handles located on the outside of the cast iron base. The top of the table consists of five metal grates which are of equal width and interchangeable. For the grid work in the metal grates, Warren used quarter inch brass rods with a two and one-half inch mesh. The grid work on the Wolbach table is constructed of cadmium-plated metal rods with a one inch mesh. The top of a sponge basin which forms one half of one of the grates is on a level with the rest of the grate and more than an inch below the level of the top of the table. This arrangement prevents needless splashing and permits the saving of table space usually devoted to a sponge basin. Because the five grates are interchangeable the sponge basin may be brought to either the left or the right side of the table or nearer to either end of the table.

Occupying the entire width of the head of the table is a catch basin for the collection of blood and fluids which are lost during the removal of the brain. This basin is also constructed of monel metal and has sloping sides and floor so that fluids pass directly into the main portion of the table to the drain. At the head end there is a head rest which is completely adjustable to any position or height. Constructed of monel metal, it rests on a long rod of similar material which is held in a bracket riveted to the table. A number of such brackets placed at intervals along the entire width permit the adjustment of the head holder at various distances from the edge of the table. The entire table may be turned to any point in a complete circle to adjust for light. The height of the table may be regulated thirty-two to forty inches above the floor by simple turning of the upper part of the table. The base of the table which is attached to the floor, contains an inner screw graduated in half inch threads. Two complete turns of the upper part of the table raise or lower the table one inch.

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The edge of the table is raised one inch above the grating to prevent spilling of fluid. There are no ledges, crevices, or rough edges where dirt or purulent material may collect. A pipe with multiple perforations may be placed around the inside of the table just beneath the table edge. From this perforated pipe a steady shower of water may flow during the autopsy. The funnel-shaped sides of the table can thus be subjected to continual washing so that blood and other material will not collect. The entire upper portion of the table may be freed from the base by the removal of three bolts. It may then be lifted from the base to expose the plumbing. A ventilation duct may be conveniently constructed in the hollow base. The duct, connected with a fan on the roof of the building, carries off the odors from the autopsy table.

Autopsy instruments may be placed on an instrument stand of the type used by surgeons or on a short-legged table which straddles the lower part of the body. The space around the table should be kept free to accommodate onlookers. Organs removed from the body are sectioned on a wooden platter. A cork or wooden mat placed on the floor beside the table spares the feet of the operator from the hard floor. Conveniently arranged around the autopsy room may be the following:

1. A monel metal sink with a deep bowl where the intestines may be opened and examined. The drain should contain perforations large enough to permit the passage of intestinal contents. Attached to the sink is a long monel metal bench, on which are conveniently placed a standard scale, a cutting board, and bottles containing fixing fluids. The scale should be of the automatic variety with a face graduated in two-gram units. The wooden platter used for sectioning of organs may be made from a bread board which has been treated with paraffin.
2. Two lavatories with deep bowls. These should be equipped with arm handles or foot pedals for regulation of the flow and temperature of the water. The two wash bowls may be labelled respectively, *dirty* and *clean*. The dirty one should be used only for cleaning used

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rubber gloves while still on the hands of the operator. The second, or clean wash bowl, is used for washing the hands and arms of the operator after the removal of the rubber gloves.

3. A wire basket to the left of the first wash bowl for the collection of discarded gloves.
4. Shelves in convenient places about the room. One shelf should contain bottles of crude carbolic acid and ten percent argyrol solution. Stock bottles of Zenker's fixative, ten percent formalin solution, glacial acetic acid, Lugol's iodine solution, and other commonly used fluids may line a number of shelves.
5. An instrument case placed near the autopsy table. It may be covered by white enamel and furnished with glass shelves and doors. Instruments should be arranged neatly on the shelves.
6. A wagon table on wheels for the transportation of bodies from the cold room to the autopsy table. The wagon should be as high as the top of the autopsy table so that unnecessary lifting may be avoided. Monel metal constitutes a durable material for the top.
7. A number of conveniently arranged electrical outlets in different parts of the room.
8. A high bench fitted with table drawers for aprons, towels and small accessory equipment. The bench should have a broad top on which are placed the various articles necessary for the taking of bacteriologic cultures.
9. A long black laboratory bench, thirty inches in height, and extending beneath the windows along one entire wall of the room. Demonstrations, both gross and microscopic, may be set up on this table for teaching purposes.
10. A large number of pans for the storage of organs which are to be demonstrated. These pans are conveniently stored on a simple steel rack painted to match the color of the walls. The best type of pan contains an inner tray equipped with handles, perforated bottoms, and short legs which let the bottom of the inner tray rest

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about one inch above the bottom of the pan. This arrangement permits blood and fluid which drip from the organs to drain from the tray to the pan below.

11. A refrigerator or cold room for the storage of bodies. Two general schemes are in use. The most convenient and sanitary method is afforded by the use of a cold room which communicates with the autopsy room. Bodies are stored on wagon tables with monel metal tops. The wagon tables serve also as a means of transportation of the body to the autopsy table. The walls of a cold room should have several layers of thick cork insulation with dead spaces between the layers of cork. We have found a temperature of two degrees centigrade (about thirty-six degrees Fahrenheit) most satisfactory, although some pathologists prefer a slightly higher temperature.

The second method of storing bodies is by means of a refrigerator which is built into one wall of the autopsy room and which extends into an adjoining room. Doors on one side permit the removal of the body to the autopsy room; doors which open into an adjoining room allow the removal of the body by the undertaker or the insertion of the body into the refrigerator. A number of compartments may be built into such a refrigerator. The bodies lie on metal slabs which are placed on rollers. The slabs should be on the same level as the transportation wagon top so that bodies may be removed without awkwardness. The lower compartments in the refrigerator may be used for storage of organs in the pans described above and the higher compartments for the storage of culture media.

The refrigerator arrangement is favored in small institutions. The cold room, which is kept clean more easily, is far more practical for large hospitals. The wagon tables may be removed and the entire room washed down by means of a hose. Drains should be located in the floor for this purpose. In some large in-

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stitutes of pathology the cold room is found in the basement and the autopsy room on the first floor. Bodies are brought to the autopsy room on an elevator. This is an unnecessarily awkward arrangement.

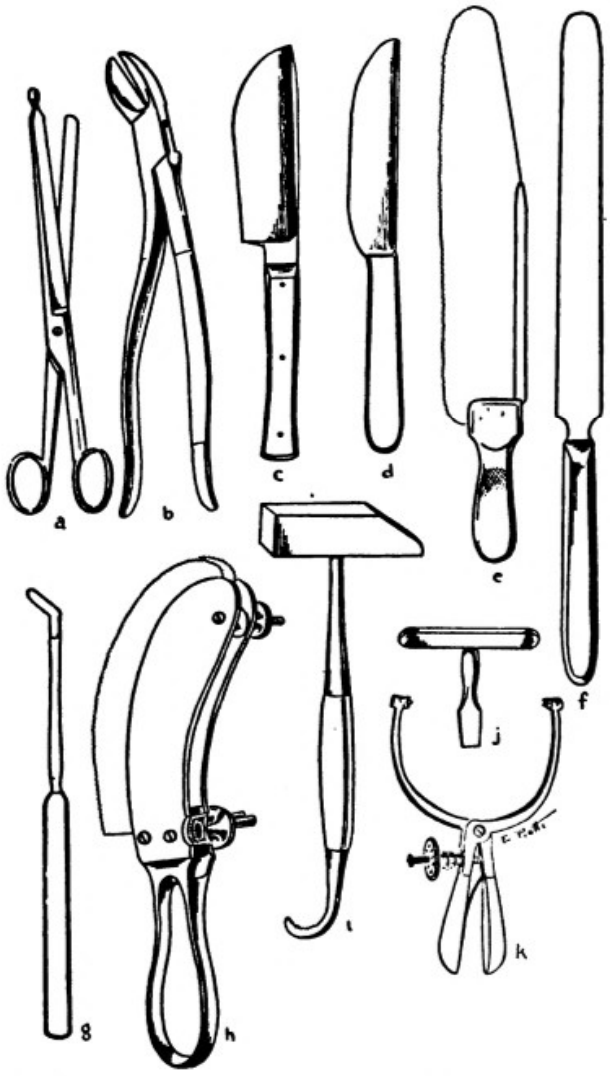

FIG. 1. Some important and useful autopsy instruments (see text).

12. A large scale built into the floor at one end of the autopsy room. The transportation wagon on which the body rests is rolled upon the scale and the weight of the body is thus determined.
13. A frozen section apparatus in a suitable corner of the

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room. House officers should be encouraged to perform frozen sections during the course of a postmortem examination.

14. Pieces of apparatus for sterilizing towels, aprons, rubber gloves and autopsy instruments.
15. Well-screened windows and doors.
16. A wall clock.
17. A suitable wall inscription, very often in Latin (for example, *Mortui vivos docent*).
18. Ventilators. The details for the individual case are best obtained from experts.

2. INSTRUMENTS. The following instruments are useful in the performance of a complete autopsy. Not all of them are always necessary. It is well to have two groups of instruments, a small one consisting of the minimum number necessary for the performance of the usual autopsy and a larger one which is stored in the instrument cabinet and called upon only for special procedures. ***All instruments should have rounded tips.*** No sharp points should be permitted since they serve no useful purpose and constitute a source of danger to the operator. The instruments may be listed as follows:

1. The autopsy knife or primary incision knife. The blade measures twelve centimeters in length and three centimeters in width; the handle, twelve centimeters in length. Two popular types are available: Gannet's knife (Fig. 1c) with an ebony handle and MacCallum's knife (Fig. 1d), with a hollow metal handle and a narrower blade. This knife is used in making the primary incision and in removing most of the organs from the body.
2. A small autopsy knife also known as a cartilage knife, with a raspatory inserted in the end of the ebony handle. This knife is used for finer dissection and for cutting through cartilage. It should be about one half the dimensions of the large autopsy knife. The raspatory at the end of the knife is useful for scraping the periosteum from the skull before the saw incisions are made.

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3. A long flat brain knife with a double edge (Fig. 1f). This is used only for sectioning either the fresh or fixed brain.
4. Enterotomes or enterostomy scissors, in several different sizes (Fig. 1a). The lower blade should have a beaded tip rather than a hook. Although designed for the opening of the intestines, the enterotome may be used conveniently for the opening of the heart and the larger blood vessels.
5. Dissecting scissors of varying sizes with both curved and straight blades. The curved dissecting scissors are extremely valuable in the dissection of blood vessels and finer structures.
6. Artery scissors with fine blades for opening small blood vessels.
7. Scalpels for fine dissection. The type with removable blades with rounded ends is to be preferred to the old fashioned scalpel. In autopsies on infants the scalpel may be used instead of the larger autopsy knives.
8. Forceps for aid in dissection. These should be the mouse-tooth and the plain type.
9. A set of probes of various measured diameters and one grooved director.
10. One costotome or heavy bone scissors. This is used for cutting through the ribs when the costochondral junctions are ossified.
11. Councilman's extra heavy bone forceps for breaking through the petrous portion of the temporal bone in exposing the ear drum (Fig. 1b).
12. Chisels. There are two types, the plain heavy post-mortem chisel and the Councilman type, which has a fiber handle and is of hatchet shape.
13. One Virchow chisel with a transverse handle (Fig. 1j). This is used for springing apart the sawed skull.
14. One wooden mallet and one steel hammer. The steel hammer has one side fashioned in the form of a wedge; a broad hook is attached to the end of the handle

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(Fig. 1i). This instrument has two uses in addition to the hammer function. The wedge-shaped edge may be used for springing apart the sawed skull and the hook attached to the handle may be inserted into the saw cut to permit the use of traction in the removal of the calvarium.

15. Surgical hemostatic forceps (for example, Kelly) of various sizes for clamping off the bowel, cut ends of blood vessels, etc. A large number should be available.
16. One flat saw of the foxtail type (Fig. 1e). This should have a fiber handle. An electrically driven revolving saw. This is a desirable but not a necessary instrument.
17. One scoop ladle.
18. Autopsy needles, both straight and curved.
19. Glass graduates for measuring fluids (100, 500 and 1000 c.c.)
20. A metal ruler marked in centimeters for measuring organs.
21. Luer's double rachiotome or adjustable double saw (Fig. 1h). This is a safe and useful instrument in the removal of the cord.
22. One myelotome (Friedel Pick). This has a short, thin, narrow blade, approximately one and one-half centimeters in length and four millimeters in width. The blade is set obliquely on a slender steel stalk (Fig. 1g). The handle may be of wood, fiber or metal. Its only use is in cutting the cervical cord square across in the removal of the brain.
23. One Bigelow holder for use in the removal of the calvarium (Fig. 1k).

In addition to these instruments a number of other articles or pieces of apparatus are useful. The autopsy aprons should be of white linen. Ordinary thin surgical rubber gloves which reach to the wrists are the most useful. Several pairs of long obstetrical gloves which extend to the elbows should always be available. Ordinary unscented talcum powder should be dusted on the hands before the gloves are drawn on. A bottle

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of Lugol's solution for the determination of amyloid and small bottles containing red and blue litmus paper are indispensable to the autopsy kit. Sterile pipettes (five cubic centimeter capacity) with rubber tops should be stored in a convenient tray. These are used in taking blood for routine blood cultures. A platinum loop, a Bunsen burner, a tripod, and a small pan in which to boil water complete the necessary bacteriologic equipment in the postmortem room. A hand magnifying glass is often of great aid toward the recognition of minute pathologic changes at the time of autopsy.

Instruments may be sterilized by a variety of methods. Ordinary boiling of instruments is not to be recommended since it rusts the instruments and dulls their edges. The following method of sterilizing instruments has been tried for several years with no objectionable results. The instruments are boiled for twenty minutes in liquid albolene in a sterilizer, the heat for which is supplied by an electric plate. The liquid albolene, which is fairly inexpensive, may be used over and over again for weeks before it need be replaced. All instruments should be sterilized after each autopsy.

REFERENCES

1. WARREN, SHIELDS: A Modified Type of Autopsy Table, Arch. Path. & Lab. Med., 4:771, 1927.

See also:

WARWICK, MARGARET: A Modern Autopsy Table, Arch. Path., 14:376, 1932.

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CHAPTER IV

REGULATIONS GOVERNING THE POSTMORTEM EXAMINATION

A THOROUGH knowledge of the clinical history is essential before the examination begins. The doctor who cared for the patient should be in attendance at the autopsy. It is obvious that the more the operator knows about the problems which confronted the clinician the more intelligently he can perform the autopsy. It is of great value for the pathologist to be familiar with the living patients. Regular visits to the wards will serve to arouse greater interest in the case as a whole and to raise postmortem examinations from the tedium of pure routine.

A few general rules governing the performance of an autopsy have proved of value.

1. GENERAL RULES. The thorough autopsy depends upon a clean and orderly procedure. Pathologic changes can be seen only when the operative field is clear. Soiling of the body and of the hair with blood or exudate should be avoided. Plenty of running luke warm water should be available to cleanse all soiled areas immediately. This problem should be attended to periodically throughout the course of the examination. The use of clamps or ligatures will prevent the escape of the contents of vessels or viscera when such structures are cut or removed. By the use of a suction apparatus blood or fluids may be drawn off. If a suction apparatus is not available small glass graduates or a ladle may be used.

To keep the instruments clean and available at all times during the autopsy the following practice is recommended. The instrument to be used is selected from an orderly array on the instrument table, and dipped into luke warm water so that tissues will not cling to the blade. Immediately after use the instrument is dipped into water again, to rinse off blood and other material which might collect upon the blade. The instru-

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ment is then returned to its proper place on the instrument table. If this routine is followed without fail the instruments will always be clean and ready for use. Furthermore, accidents will be minimized. A common injury occurs when the operator is cut by the tip of a knife left carelessly in a body cavity. At no time should instruments be placed upon the legs of the patient. The operator should execute each incision in clear view, and with the sequence of the examination well in mind. Special care should be exercised to prevent accidental cuts if an assistant is present at the examination. A postmortem examination should be carried out by the operator and his assistant with the precision and order characteristic of a surgical procedure. All incisions should be planned with later reconstruction of the body in mind.

Once the operator has donned rubber gloves he must touch no object which is to be handled later by bare hands. In autopsy rooms where this rule is not enforced pathogenic organisms are spread to all parts of the autopsy room, to door knobs, drawer handles, wash bowls, telephones, and other objects. Spectators should not be permitted to touch organs with their bare hands, or to lean against the autopsy table. Carelessness in the autopsy room on the part of the operator or the clinical visitor should be prevented by the strict enforcement of inflexible rules. A "contamination conscience" equivalent to that in the surgical operating room should prevail in every autopsy room.

The following slight refinement in technique has proved of value. After the external examination of the body has been made, the face of the patient is covered with a towel secured behind the head by a clamp or towel clip. Similarly, a towel is placed across the legs, over the genitalia. This procedure takes but a moment and adds dignity to the examination.

2. DRESS. It is customary in most laboratories to wear an ordinary shirt with the sleeves rolled above the elbows. A surgical shirt with short sleeves may be worn if preferred. The lower arms are kept free for the full efficiency of the operator. If the examination is properly conducted, the arms need not be

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protected against soiling. White trousers made of cotton afford more comfort to the operator and if soiled can be more easily cleaned than ordinary trousers. The clothes of the operator are covered by a linen apron. If a waterproof apron is desired in addition to the linen apron, it should be worn beneath the linen apron, since the cloth garment can be sterilized more easily. In many places waterproof aprons alone are used. This is an unclean practice. A waterproof apron is unnecessary if an examination is properly carried out without splashing of fluids or spilling of blood. The linen apron is donned before the gloves are drawn on, and removed after the gloves have been washed and pulled off. With a little dexterity the apron can be removed so that the soiled portions do not touch the bare hands. The apron, deposited in a suitable container, is later sterilized and then washed. Under certain conditions (if children are encouraged to crawl about the floors at home), it may be advisable to have a separate pair of shoes for use in the autopsy room. Rubber boots are not necessary if the autopsy room is well regulated.

3. CARE OF THE HANDS. The heroic days of the "bare-handed" postmortem examination is over. No autopsy should be performed and no organ should be touched without rubber gloves. This rule applies to the operator, the onlookers, and the autopsy orderlies. Thin surgical rubber gloves which reach just above the wrist have proved the type of choice. They protect the hands completely and yet do not detract in any important degree from the sense of touch. If a small amount of talcum powder is dusted into the gloves and onto the hands, the gloves may be drawn on without difficulty. After the autopsy the gloves are washed thoroughly with warm water before disposal, in order that blood may be removed before it dries. The gloves are sterilized in the dry oven or in the autoclave. They are then dried, if necessary, inflated and subjected to the water test, by which means holes can be readily detected. If holes are found the gloves are patched and tested again. They are then rolled up neatly in pairs and stored away for further use.

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Thin linen gloves have been used by a number of pathologists, notably Fischer-Wasels of Frankfurt. They are placed over the rubber gloves and secured by a band above the wrist. Blood and tissue particles will not adhere to the cloth gloves if the gloved hands are soaked in water and the gloves wrung out at intervals during the autopsy. Although cloth gloves are less slippery than rubber gloves, they are not a necessity and are indeed considered by some to be a nuisance. Long rubber gloves which reach to the elbows are of value in cases of restricted autopsies when the thoracic organs must be removed through an abdominal incision. They are not necessary in the usual unrestricted examination.

When the rubber gloves have been removed after the autopsy, the hands and arms are washed with running water and liquid soap for five minutes. Scrubbing brushes, the fine hairs of which may infect the skin by way of minute scratches, should not be permitted in the autopsy room. The hands and arms may now be rinsed with seventy percent alcohol. Further care is superfluous. No deodorant for the hands is necessary if gloves have been worn.

4. INFECTIONS. Accidental autopsy infections are usually caused by careless technique on the part of the operator, the use of torn or unclean gloves, or the employment of knives and scissors with sharp points instead of the rounded-off tips recommended above. The following procedure in accidental piercing of the skin during an autopsy has proved of great value. As soon as the operator's glove is pierced by an instrument the examination should be stopped, the gloves removed and the hands inspected. If the skin has been cut the wound should be washed in running hot water and encouraged to bleed freely. A sharp-pointed match stick which has been dipped into crude carbolic acid is then bored into the wound. This treatment is followed by careful washing with seventy percent alcohol and binding of the wound. The operator may then draw on clean gloves and continue the examination. Tincture of iodine is not recommended in instances of accidental piercing of the skin.

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Very often the injury to the skin may be so slight as to escape notice and an infection may set in. At the first sign of infection (inflammation, pain in the arm or axilla, red stripes on the flexor surface of the arm, fever, general malaise), the hand and arm should be immobilized. At such a time conservative treatment by an experienced surgeon is essential. If blood or purulent material is splashed into the eyes, a few drops of ten percent argyrol solution should be instilled immediately.

5. TECHNICAL RULES. The operator stands on the right side of the table (or the left if the operator be left handed) and does not leave this position except for a definite purpose, as for example, when he goes to the head of the table to open the skull. All the necessary instruments, solutions and materials which will be needed in the course of the examination should be within reach of the operator as he stands in his correct position. If a blackboard is on the wall near the table, and if no assistant is present to take down notes, the operator may use chalk which comes from a "dirty" box and may use an eraser which is marked "contaminated." Clean chalk and a fresh eraser should be available for the use of other persons in the autopsy room who are not wearing rubber gloves.

The knife is held in the full hand with the thumb on one side and the four fingers on the other, except in deep dissection when it is held like a pen. In cutting, the knife is drawn firmly and evenly and is never pressed or shoved into the tissues. A broad, clean cut, even if incorrectly made, is to be preferred to several short, jagged cuts which leave a rough surface. The incision begins with the heel of the blade and ends with the tip. The main movement in cutting should be from the shoulder, whereas in dissection the movement is from the wrist. Scissors are held so that the thumb is in the upper loop and the middle finger in the lower loop; the forefinger acts as a guide. Some pathologists prefer to place the ring finger in the lower loop and to use two fingers as guides. The cut surfaces of the organs should not be washed with water, lest they be spoiled thereby for successful histologic preparations. The cut surfaces of the

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organs may be cleaned sufficiently by gentle strokes of the knife edge. If necessary, the surfaces of the tissues may be washed lightly with normal saline solution.

6. BACTERIOLOGIC CULTURES. Blood is removed for culture before the organs are disturbed. After the primary incision has been made and the thoracic and abdominal cavities laid free, the pericardial sac is opened. The right auricular appendage is brought into view and held in place by means of a clamp. The anterior surface of the right auricle is then seared by a heated knife, and the needle of a sterile syringe is plunged into the auricle. A sterile pipette may be substituted for the syringe but in this case a heated knife blade held in a clamp is used to make a small incision in the center of the seared surface of the auricle. The pipette may be inserted from the right auricle through the mouth of the tricuspid valve into the right ventricle. If sufficient fluid blood is not present the pipette may be inserted from the auricle into the inferior vena cava and the blood may be forced upward from below. The removed blood is placed immediately into suitable media.

Material may be removed for culture from the spleen, liver, intestinal tract or other organs by modifications of this procedure. In all cases, the surface is seared and an incision into the organ or viscus is made with a sterile knife. Portions of organs or contents of viscera are then removed and transferred to suitable media.[1, 2, 3]

7. THE SPECIFIC TASKS OF THE OPERATOR. The order of procedure in the routine postmortem is given below in outline for the assistance of the young pathologist. Deviations from this routine are to be expected in all unusual cases. During the examination the operator must decide which technique is best suited to the particular examination. Let us begin with the first step in the performance of a typical autopsy and carry through to the end of the examination.

1. Verify the autopsy permission.
2. Read the clinical history and confer with the clinician in charge of the patient in regard to special problems.
3. Examine the outside of the body. Make necessary

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measurements. Note the degree of rigor mortis, post-mortem lividity, and so forth.

4. Make the primary incision and dissect back the skin and musculature over the thorax.
5. Inspect the contents of the peritoneal and pelvic cavities.
6. Measure the height of the diaphragm.
7. Remove the sternum.
8. Inspect the contents of the pleural cavities and the mediastinum.
9. Open the pericardial sac.
10. Draw blood for culture from the right auricle.
11. Open the pulmonary artery *in situ*.
12. Remove the thymus.
13. Ligate and sever the great vessels (the innominate, the left common carotid and the left subclavian arteries).
14. Remove the heart, the left lung, and the right lung.
15. Remove the tongue, the neck organs and esophagus and trachea (with or without the thoracic aorta) in one piece.
16. Open the lesser peritoneal cavity. Determine the patency of the foramen of Winslow.
17. Inspect the portal vein and its branches.
18. Remove the spleen after inspection of the splenic vein and splenic artery.
19. Ligate and cut the bowel at the junction of the rectum and the sigmoid colon and at the junction of the jejunum and duodenum. Inspect the mesenteric vessels. Remove the intestines from the body after separation at the mesenteric border.
20. Open the duodenum *in situ*. Probe the common bile duct and the pancreatic duct.
21. Investigate the inferior vena cava and its branches *in situ*.
22. Sever the liver from its connections with the body and remove the organ.
23. Remove the stomach, duodenum and pancreas in one piece.
24. Remove the adrenal glands.

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25. Remove both kidneys after determining the condition of the renal vessels and the ureters.
26. Remove the organs of the pelvis in one piece.
27. Open the abdominal (or entire) aorta *in situ*. Make the test for elasticity and remove the aorta.
28. Open the iliac arteries and, when indicated, the femoral vessels.
29. Remove the lymph nodes from the inguinal, axillary and cervical regions.
30. Incise the scalp.
31. Retract the scalp and scrape the periosteum from the calvarium.
32. Remove the calvarium after suitable saw cuts have been made.
33. Examine and reflect the dura.
34. Inspect the convexity of the brain.
35. Open the longitudinal sinus.
36. Remove the brain after cutting through the tentorium on each side and severing the cervical cord from the brain stem.
37. Remove the pituitary gland.
38. Open the venous sinuses of the skull.
39. Strip the dura from the base of the skull. Inspect the base of the skull.
40. Expose and inspect the middle ears and the mastoid antra.
41. Expose and inspect the air sinuses of the skull.
42. When indicated, expose and remove the posterior half of the eye.
43. Remove the spinal cord.
44. Remove bone marrow from the sternum, ribs and vertebral bodies. Inspect and remove as much of the skeleton as is permitted.
45. Open, examine, and weigh all organs. Make all necessary measurements.
46. Select and remove representative sections for histologic examination. Use special fixing solutions when indicated.

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47. Preserve valuable gross specimens for demonstration purposes.
48. Reconstruct the body and return it to the cold room.
49. Write or dictate a protocol from notes made during the examination if the protocol has not been dictated during examination.
50. List the gross diagnoses.

REFERENCES

1. BURNS, CASPAR G.: (a) Postmortem Bacteriology, Jour. Inf. Dis., **54**:395, 1934. (b) Experimental Studies of Postmortem Invasion in Animals, Jour. Inf. Dis., **54**:388, 1934.
2. HUNT, H. F., BARROW, E., THOMPSON, L., and WALDRON, G. W.: Bacteriologic Study of 567 Postmortem Examinations, J. Lab. & Clin. Med., **14**:907, 1929.
3. GIORDANO, A. S., and BARNES, A. R.: Studies in Postmortem Bacteriology, J. Lab. & Clin. Med., **7**:538 (June) 1922.

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CHAPTER V

INSPECTION OF THE BODY

1. EXTERNAL EXAMINATION. With main emphasis on inspection and palpation, the external examination of the dead body follows the lines of a systematic clinical physical examination. Proceeding in a definite manner, it omits no observation of importance. Length and weight of the body are determined by actual measurement. The length is measured in centimeters from the vertex of the skull to the sole of the foot beneath the ankle. The sex and race of the patient are recorded. An estimate of the age is made, and a note is recorded of any discrepancy between the apparent and the actual age of the patient. The body is appraised in reference to the state of nutrition, development and proportions of the various parts. The presence and the distribution of rigor mortis are observed by palpation of all muscles of the body from the eyelids to the feet. Notes are then made on the color, texture, length, amount and distribution of the hair over the head and all other parts of the body. The skin is next examined for exact color, texture, elasticity, amount of subcutaneous fat and evidence of loss of subcutaneous fat. Any scars, lacerations, incisions, needle puncture wounds, scratches, areas of pigmentation, tumors, discolorations, rashes, inflammatory lesions or other skin lesions are measured and described.

The condition of the nails of the fingers and toes is noted. By careful palpation, possible enlargement of lymph nodes in the inguinal, axillary, cervical, supraclavicular and other regions of the body is determined. Evidences of edema are sought on all body surfaces, particularly over the dorsum of the foot, the ankles and the hands, and beneath the eyes.

The examination is then continued with an inspection of the head. Particular attention is paid to the presence of lacerations or parasites in the scalp. The ears, nasal passages, eyes and

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mouth are inspected for their general appearance and the presence of exudate, hemorrhage, or anomalies in structure. The eyes are examined particularly in regard to the size and shape of the pupils and the color and appearance of the corneae and sclerae. The diameter of the pupils is measured by a millimeter rule placed over the eye. A note is made on the roundness, regularity and equality of the pupils. The eyes may be prominent or depressed within the orbital space. After the color of the mucous membrane of the mouth has been recorded, the teeth are examined in great detail with reference especially to the number, the names of missing teeth, the presence of artificial dentures, evidences of caries, and the location of fillings or inlays. The gums are next inspected. If the jaw is not involved by rigor mortis a view of the throat may be obtained.

The mammary glands are palpated and inspected for evidences of inflammation, tumors and lactation. Particular attention is now paid to the shape of the thorax, and the condition of the ribs. By palpation of the abdomen, the presence of possible distention, fluid wave, or palpable masses is detected. The skin over the abdomen is searched for old operative incisions and the umbilicus for evidence of infection or herniation. After the inguinal regions have been palpated, the genitalia should be exposed and inspected externally. It has been recommended, particularly by Cattell, that the female cadaver be placed in lithotomy position for careful examination of the genitalia. In the male the presence or absence of testes may be ascertained by palpation. The anus is inspected, particularly for evidence of varicosities or fistulae. The legs and the feet are now inspected in detail.

The body is then turned over for a more careful examination. The amount and distribution of postmortem lividity may now be determined. The presence of decubitus ulcers, congenital malformations over the lower portions of the spine, fissures, sinuses and skin lesions is noted.

The body must be identified in every case. This is best performed by the doctor who cared for the patient. It would be an excellent but unfortunately impracticable procedure to

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begin every autopsy with a photograph of the body. The description of the external markings should be so accurate, however, that identification may be made in the event of later dispute. When a postmortem examination is made on an unidentified body a photograph of the body should be taken, and, if possible, finger prints should be recorded in the usual police manner. A record of the condition of the teeth and of the exact location and character of operative incisions, may be of aid in later identification.

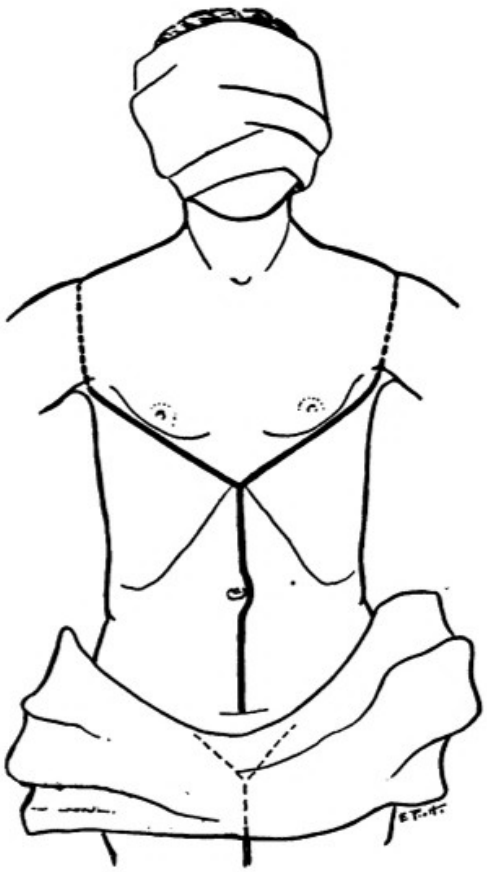

FIG. 2. The Y-shaped primary incision. The face and the genitalia have been covered by towels.

2. PRIMARY INCISION. The primary incision should be made with the problem of reconstruction of the body in mind. There should be no visible evidence of the incision after the corpse has been dressed, even though décolleté garments are used. Several types of primary incision are in wide use. Only one, commonly known as the Y-shaped incision, fulfills all requirements (Fig. 2). The incision begins in the skin over the right acromion process and passes downward with a slight curve a few centimeters below the mammary gland to the xiphoid process. It is continued from the xiphoid beneath the left breast to a point over the left acromion process. A second incision begins at the xiphoid process in the line of the first cut, passes down the midline of the body over the abdominal wall, deviates slightly to the left around the umbilicus and ends at the symphysis pubis. The vessels of the extremities may be

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examined by simple prolongations of the primary incision to each leg. This incision of choice meets the demands of the pathologist and removes the important objections of the undertakers and relatives.

There are three other methods of making the primary incision.

Method one is widely used and consists of two cuts, the first of which passes from the suprasternal notch down the midline of the body to the symphysis pubis with a slight deviation to the left around the umbilicus. The second incision, perpendicular to the first, is carried from one acromion process to the other. The sole objection to this method is that the high position of the transverse arm of the incision is unfavorable to a possible décolletage of burial dress.

Method two consists of a single incision which begins at the symphysis of the mandible and passes down the midline of the body to end at the symphysis pubis. This type of incision, although of great convenience to the operator, is obviously undesirable because the mark of the incision will be noticeable after the body has been dressed.

Method three was devised by Fischer-Wasels. The incision begins at the left mastoid process and is carried down along the lower border of the sternocleidomastoid muscle to the suprasternal notch. From this point it is carried down the midline of the body with a deviation to the left around the umbilicus. Just below the umbilicus, the incision divides in two directions to pass on each side to the legs. The advantage claimed for this method is the free approach to the neck organs and the continuity of the scalp incision, beginning at the left mastoid process, with the primary incision. When the incision has been sutured, no sign of it will be evident if the head of the corpse is turned slightly to the left.

A variation of the Y-shaped primary incision may be carried out in children when particularly careful examination of the umbilical vessels is desired, or in individuals of any age when an abdominal operative incision is to be examined from the inner aspect of the abdominal wall (Fig. 3). The usual primary in-

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cision is made over the thorax and continued in the midline to a point approximately four centimeters below the xiphoid process where the incision forks to the right and left. The branches are carried to the lateral margins of the abdominal wall and thence to the crest of the ilium. The resultant cut is an inverted U in shape. A flap turned back over the genitalia

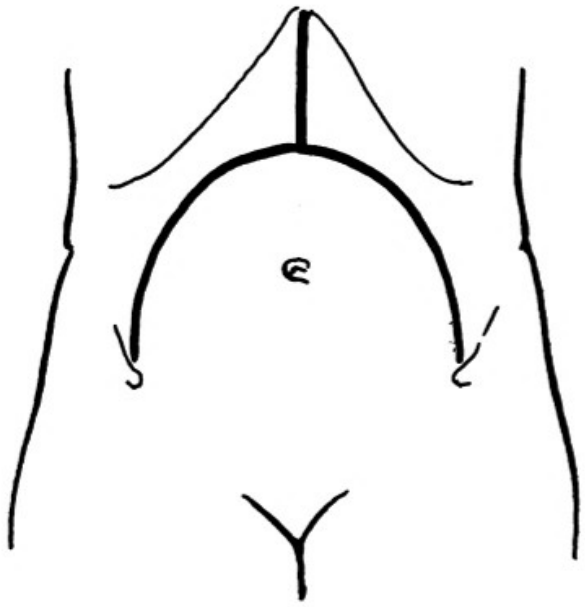

FIG. 3. Variation of the Y-shaped incision for use in postmortem examinations on infants and on patients with laparotomy wounds.

reveals the inner aspects of the abdominal wall and, in infants, the umbilical vessels.

The primary incision is made with a large knife, two separate strokes of which are required for the Y-shaped incision. Over the thorax the incision is carried through the skin, subcutaneous fat and muscles down to the ribs, but not into the intercostal muscles. The knife is held with the handle depressed so that blade and handle are almost in one line. The point of the blade is never directed downward. The incision over the abdomen passes through skin and subcutaneous tissue and is carried as far as, but not through, the peritoneum. The beginner may have to make several light strokes of the knife blade over

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the abdomen before he can judge accurately the required amount of pressure. After a small button-hole incision has been made in the peritoneum at a point just below the xiphoid process, note is made of exudate, gas, or fluid which may escape. Cultures of a possible exudate must be obtained without contamination.

The first two fingers of the left hand of the operator are now inserted into the peritoneal cavity through the small opening which has been made, and the fingers are directed toward the symphysis pubis. The fingers raise the peritoneum from within and thus tauten the peritoneum. The peritoneum is then opened either by a knife with an upturned blade or by a pair of beaded scissors held in the right hand and inserted between the two opened fingers of the left hand. In this position, with both hands moving together toward the symphysis, the operator opens the peritoneal cavity along the line of the primary incision. If a wider exposure of the peritoneal cavity is desired, the rectus and pyramidal muscles at the lower end of the abdominal incision are split by transverse incisions made from the inner aspect of the abdominal wall. Similar incisions may be made when necessary through the muscles at the upper end of the abdominal incision. The overlying skin must constantly be protected against injury.

A more liberal exposure of the contents of the abdominal cavity is now afforded by the dissection of the skin and underlying muscles from the thorax to the axillary line. First, the dorsum of the left hand is placed on the skin over the lower border of the ribs. Then the edge of the cut skin and muscles is grasped by the thumb of the left hand, and drawn forcefully over the costal arch so that the dorsum of the hand may lie flat on the skin. This procedure has the advantage of protecting the left hand by the fold of skin and muscles from accidental cuts. Furthermore the resultant fold in the wall provides a landmark for dissection, since all connections between the ribs and overlying tissues are made taut. By means of long sweeps of the cartilage knife which is held almost flat, all connections are severed as close to the ribs as possible without incision of the

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intercostal spaces. The thoracic flap may be carried back on each side as far as the acromion process. The axillary lymph nodes and the brachial plexus may be exposed by further dissection of the lateral thoracic skin flaps.

At this point, it is advisable to free the skin and overlying tissues from the sternum. The skin and muscles are grasped by the left hand in the manner used in the dissection of the lateral thoracic flaps, and are drawn firmly toward the chin. The dissection is carried to a point just above the clavicles. The skin over the throat is usually not freed until the sternum has been removed.

Before any further procedures, the advisability of special technique should be considered. If a pneumothorax has been detected during life or is suspected from the clinical history, the procedure of Breslau is carried out. Into a pocket fashioned from the lateral thoracic skin flap, normal saline solution is poured. A sharp scalpel is then plunged through the intercostal muscle and pleura, without injury to the lung. If air is present in the pleural cavity it will bubble through the saline solution. The operator may have to pierce the intercostal space at a number of levels, since pockets of air may be localized by dense adhesions in the pleural cavity.

The procedure of Breslau may be used to determine the presence of air in the peritoneal cavity or in the chambers of the heart. If the presence of air in the peritoneal cavity is suspected, the usual primary incision is first made. The skin and muscles over the abdomen are then dissected laterally to form a pocket. The peritoneum is pierced by the point of a scalpel after normal saline solution has been poured into the pocket. Similarly, when evidence of air embolism is sought, the partially opened pericardial sac is used as the pocket, and the right or left auricle incised under fluid.

3. EXAMINATION OF THE ABDOMINAL CAVITY. Before the contents of the abdominal cavity are disturbed or removed a systematic inspection is made. Main stress is placed at this time on the appearance, position, and anatomic relations of organs and structures. More detailed study of the individual organs is

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deferred till such time as they have been removed from the body. The inspection of the abdominal contents *in situ* affords an opportunity for selection of the technique best suited to the particular case with reference to the later removal of the abdominal viscera. The following short outline includes the steps usually followed in a routine examination of the abdominal cavity, and a few suggestions as to procedure under unusual conditions. Fluid or purulent material in the peritoneal cavity or in the pelvis is removed and the amount measured. Material for culture is taken when the peritoneal cavity is first opened. Accumulations of purulent material are often found in the floor of the pelvis, in the right lower quadrant, in the region of the spleen and beneath the diaphragm above the liver. If the abdomen has been previously explored by surgical operation, foreign bodies may be found. Occasionally there may be calcified masses free in the peritoneal cavity, as, for example, if portions of the appendices epiploicae have become detached and have calcified.

The peritoneal surfaces are observed for their color and appearance. The surfaces are usually smooth, pale and glistening. Normally only a few drops of pale, colorless or amber fluid are present in the peritoneal cavity. The position of the liver is measured in relation to the distance from the costal margin to the lower edge of the liver in the axillary line and in the midclavicular line. The location of the left border of the liver is determined by measurement from the xiphoid process. Observation is next made on the position and length of the gall bladder. The presence of stones within the gall bladder or common duct is detected by palpation. The size of the spleen is determined in relation to the costal margin and, in instances of enlargement, to the level of the umbilicus. The great omentum is now examined for color, consistency, fat content and attachments. While it is normally non-adherent except at its point of attachment, the omentum may be adherent to an area of recent or old inflammation, as, for example, to the surface of an inflamed appendix. It often forms part of the contents of a hernial sac. The omentum is now lifted gently and reflected to permit a view of the cecum,

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appendix, small intestine and pelvic organs. When position and length of the appendix have been noted, abnormalities in the attachment or in the continuity of the gastro-intestinal tract are sought. The loops of the small intestines are viewed and palpated. If adhesions are present between the loops of bowel their nature and location are observed. They may be broken if fresh, or cut if they are old and fibrous in nature. Should the intestines be hopelessly adherent because of inflammatory exudate or tumor metastases, it is wise to defer a detailed examination until the abdominal organs have been removed *en masse*.

When evidence of peritonitis or of intestinal obstruction is found, the cause in each case must be determined *in situ*. During the examination of the small bowel attention is paid to the adjacent mesenteric lymph nodes, enlargement of which should raise a question as to the possibility of pathologic changes in the neighboring loops of small intestines. Ulcerations or tumors of the bowel are often apparent from an examination of the serosal surfaces of the bowel. If the patient died a few hours after having eaten, the lacteals are visible as delicate milk-white vessels from the serosal surface of the bowel. The mesentery of the small bowel is examined with reference to color, consistency, fat content and attachment. The mesenteric lymph nodes are palpated, viewed, and measured. The operator may determine the height of the mesentery by gathering the small intestines in one mass with the stalk held between two fingers of the left hand, and lifting the intestines from the body until the mesenteric stalk is taut. The cecum and the several portions of the large intestines are next palpated and the attachments noted.

The contents of the pelvis may now be viewed and palpated. A particular note is made of the height of the fundus of the urinary bladder in relation to the brim of the pelvis. In females the external appearance, consistency and anatomic relations of the uterus, tubes, ovaries, the ligaments of the uterus, and the pouch of Douglas are observed at this time.

After the round ligament of the liver (ligamentum teres) has been cut transversely, the presence of the lumen of a persistent

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umbilical vein is sought. The pancreas is viewed as soon as the gastrohepatic (lesser) omentum has been torn gently and the lesser peritoneal cavity exposed. The size, position, and relations of the pancreas are noted. The splenic artery and vein are palpated and their external appearance described. The kidneys and the adrenal glands are palpated at this time but are not further disturbed. The peritoneal surfaces of the diaphragm may now be examined conveniently. The liver is forced downward and the ribs are drawn up so that a clear view of the diaphragm on the right side may be obtained. A view on the left is more readily available. The surface above the liver is searched for evidence of sub-diaphragmatic abscess. Miliary tubercles are sometimes found on the peritoneal surface of the diaphragm when no other evidence of tuberculosis in the abdominal cavity is present. The examination of the abdominal cavity ends with the measurement of the height of the diaphragm. The operator may determine the height of each side by passing the right hand with fingers extended underneath the ribs as far as possible in the costochondral line, without the use of pressure, and placing the left hand on the external surface of the ribs at a point corresponding to the level of the tips of the fingers of the right hand. The height of the diaphragm is recorded in terms of ribs or intercostal spaces. The dome of the diaphragm in the costochondral line measures usually to the fifth rib on the left side and to the fourth rib or fourth interspace on the right.

The contents of the abdominal cavity are now restored as nearly as possible to their original positions, until such time as they are to be removed after the thoracic and neck organs have been taken from the body. To prevent drying of tissues during the necessary delay, the operator may cover the abdominal organs with a towel which has been moistened with normal saline solution. The thoracic cavities are now exposed by the removal of the sternum.

4. REMOVAL OF THE STERNUM. With the knife so held that the belly of the blade rests upon the rib to be cut and the heel of the blade, or the first part of the handle, rests upon the rib

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below, the operator makes transverse incisions through the ribs and intercostal muscles from the second to the tenth ribs (Fig. 4). The transverse incisions are made in one long sweep which

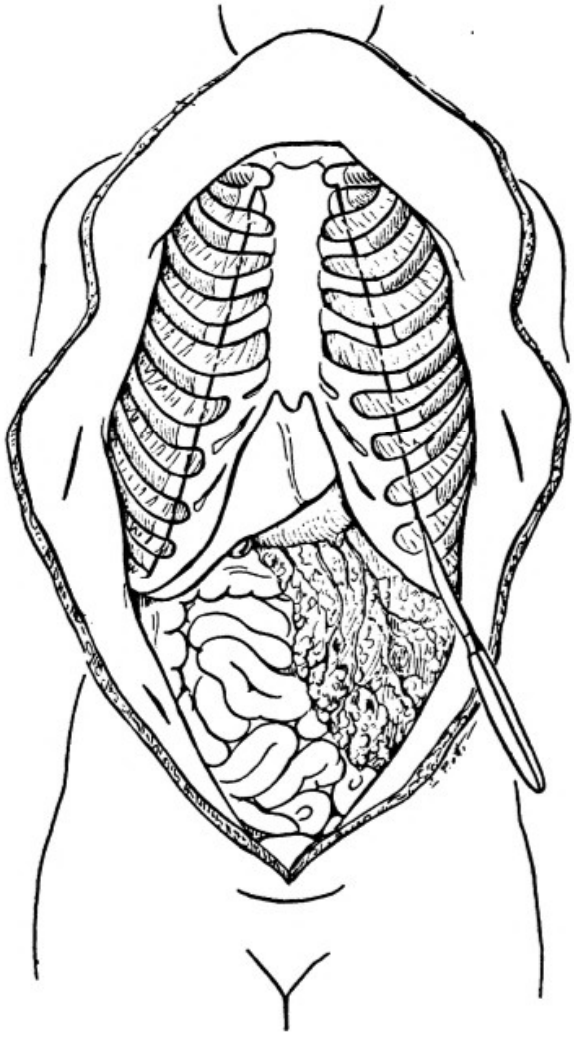

FIG. 4. Removal of the sternum. The ribs and intercostal muscles have been divided and the clavicle has been freed from the sternum.

passes obliquely outward through the cartilaginous portions of the ribs in a line approximately one centimeter medial to the costochondral junctions. In making the incision on the left side, the blade is oblique in respect to the ribs and its edge directed slightly toward the axillary line. Observance of these directions

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will prevent injury to the pericardial sac and the heart. If the ribs are completely ossified the incision is made by means of a costotome from below upward as near to the axillary line as possible.

The sternum is removed in the following manner. The sternal borders of the lowermost ribs on the left are grasped with the

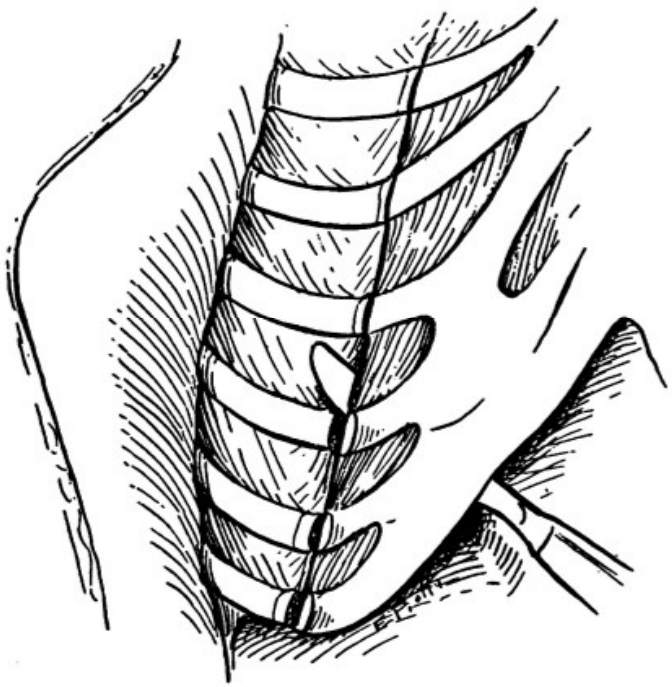

FIG. 5. Removal of the sternum. The ribs and intercostal muscles have been divided. The sternum is now being separated from its attachments to the diaphragm. The tip of the knife, which has been inserted through the diaphragm below the sternum, appears in the line of the previous incision through the ribs and intercostal muscles. The blade is directed toward the abdominal cavity.

left hand and raised. The knife is held flat, and the edge, directed toward the left, is plunged through the diaphragm at its point of insertion with the sternum (Fig. 5). By means of sawing strokes toward the left, all attachments of the sternum to the diaphragm on that side are severed. The knife blade, continuing below the sternum, finally reaches the line of incision through the ribs. The short sawing incisions are then continued

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downward between the previously cut ribs to sever any remaining fibers of the intercostal muscles. A similar procedure is carried out on the right side. The left lower border of the sternum is now grasped with the left hand and raised. The left hand does not release this hold until the sternum is removed from the body. The sternum is freed by careful dissection of all underlying tissues as pressure elevating the sternum is gradually increased. The contents of the anterior mediastinum must not be injured while the sternum is being separated from them.

The first rib is now cut through on each side and the sternum is freed from its attachment to the clavicle. Two methods are available.

Method one. The sternoclavicular joints are opened and the cartilages of the first ribs are cut by one continuous incision on each side before the sternum is freed from its attachments to the diaphragm. The clavicle articulates with the sternum and with the cartilage of the first rib. The line of articulation of the clavicle with the sternum may be readily recognized if the arm of the patient is moved or if the sternal end of the clavicle is shaken by the left hand of the operator. A scalpel with a short narrow blade is held vertically and inserted carefully into the tissues above the clavicle at a point just lateral to the attachment of the sternocleidomastoid muscle. By means of short sawing strokes the blade of the knife follows the line of the joint, passes around the head of the clavicle and then along the lower border of the clavicle, through the cartilage of the first rib. Care must be taken to avoid cutting the innominate or internal mammary veins which lie beneath the upper end of the sternum and the clavicle.

Method two. The sternoclavicular joints are opened and the first ribs are cut through after the sternum has been freed from its diaphragmatic and other attachments up to the first rib. The partially freed sternum is elevated as high as possible. The knife is placed beneath the sternum, and the blade directed upward and laterally to cut through the cartilage of the first rib. As soon as the mediastinal structures

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have been separated from the sternum, the sternoclavicular joint on the left side is opened from below. The sternum is drawn toward the right side of the body while the scalpel enters the joint and follows the irregular line of the joint. A similar procedure is then carried out in the opening of the joint on the right. This method is recommended for the beginner since it involves less risk of cutting the large veins.

After the muscles of the neck have been cut at their insertions in the sternum, the entire sternum may be removed from the body. The inner surface is examined for evidence of inflammation or new growth. The bone marrow in the manubrium may be viewed by means of a long midline incision which almost, but not completely, halves the structure.

If the costotome has been used, the ragged edges of the cut ribs afford a source of danger to the operator. To prevent accidental scratches, the operator may cover the cut ribs with a towel fastened by clips, or may draw over the edges the skin and muscles of the lateral thoracic flap.

5. EXAMINATION OF THE THORACIC CAVITY.

Pleural Cavities. Before any manipulation of the contents of the thoracic cavity occurs, the pleural cavity on each side is examined for the presence of fluid or exudate. When each lung has been lifted cautiously toward the midline, the floor and lateral walls of the pleural cavities may be examined. Cultures are taken of possible exudate. The amount of fluid or purulent material present should be measured. Note is made of the position and general appearance of the lungs and pleural surfaces, the relation of the borders of the lungs to the pericardial sac, and the amount of collapse of the lungs. The color and texture of the parietal pleura are described. The normal lung retraction, upon the opening of the thorax, does not occur when consolidation is present, when pulmonary disease affects the elasticity of the lungs, or when fibrous adhesions hold the lungs in place. The size, relations, and external appearance of the pericardial sac are next observed. The position of the thymus in relation to the pericardial sac and underlying structures is determined.

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Pericardial Cavity. The anterior portion of the pericardial sac is lifted by means of mouse-toothed forceps. The sac is then opened either by scissors or by a knife in a longitudinal incision which begins just below the point where the pericardium is reflected over the aorta, and which passes downward along the right border of the sac toward the diaphragm. Perpendicular to this incision a second one is directed toward the left and concluded above the apex of the heart. By lifting the apex of the heart carefully in the left hand, the operator may determine the amount and character of the fluid in the pericardial sac. While the heart is held in this position all surfaces of the organ may be viewed. The color and texture of the pericardial surfaces and the presence of adhesions are noted. Before any incisions are made into the heart, blood for routine bacteriologic culture is taken according to the method described above (p. 44). A

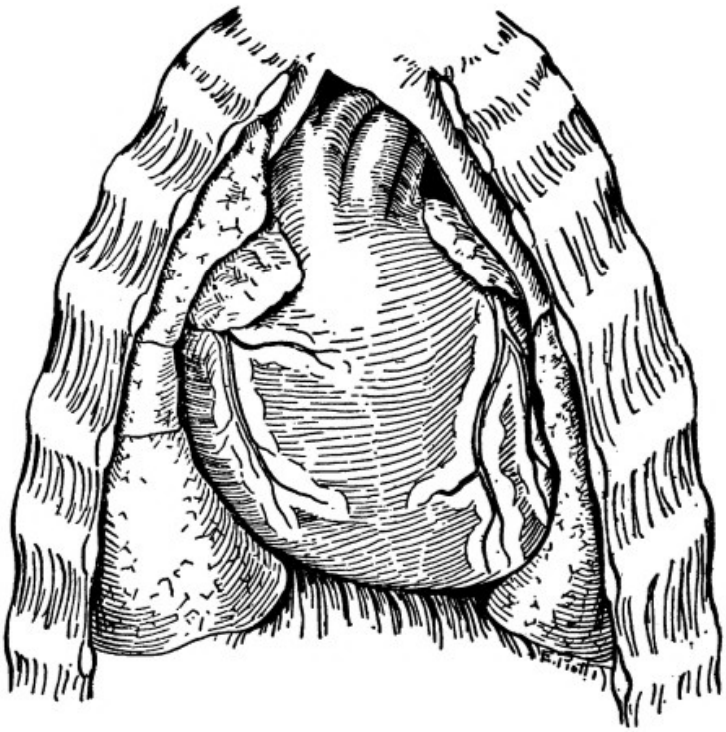

FIG. 6. The heart *in situ*. The pericardium has been cut away. The illustration shows the line of the incision which opens the pulmonary artery before the heart is removed from the body.

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single incision is then made, either with a knife or with a pair of scissors, in the pulmonary artery, from a point just above the exit of the artery from the heart and up to the artery's division into two main branches (Fig. 6). The character of the blood which flows out through this incision is noted. To determine the presence of emboli or thrombi, the operator inserts forceps gently through the incision into the pulmonary artery. If thrombi are present, the heart and lungs are not separated from one another but are removed together for the complete dissection of the pumonary vessels into the lungs.

Mediastinum. The contents of the mediastinum are viewed and palpated. Bubbles of air are frequently found in the loose areolar tissue which covers the anterior mediastinum. This is not true mediastinal emphysema but is caused by the entrance of air during the forceful separation of the sternum from the mediastinum. The presence of enlarged lymph nodes at the hilus of each lung and along the trachea may be noted by palpation. The thymus is now removed in order that the great vessels which leave the aorta and the large veins may be exposed. The removal of the thymus, which may have extensions above the suprasternal notch, is best carried out by blunt dissection with curved scissors.

Dissection of the Great Vessels. The vessels leaving the arch of the aorta are now exposed. From right to left they are: the innominate artery (which soon divides into the right subclavian and the right common carotid arteries), the left common carotid artery, and the left subclavian artery. The ductus arteriosus or ligamentum arteriosum, easily discovered between the aorta and the pulmonary artery, leaves the aorta at a point just opposite the point of exit of the left subclavian artery from the aorta. The great vessels are freed by blunt dissection with curved scissors, to a point about two to four centimeters from their exit from the arch of the aorta. The arteries are severed below ligatures placed around each of the great vessels. A single tie may be used for the innominate artery. For higher dissection, ties should be placed on both the right subclavian artery and the right common carotid artery. The long pieces of string hanging

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free from the tied ends of the vessels may be drawn from the operative field by Kelly clamps. When the body is later reconstructed the strings are pulled through the line of sutures to the outside of the body so that the vessels may be found easily by the undertaker.

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CHAPTER VI

REMOVAL OF THE VISCERA

1. REMOVAL OF THE THORACIC ORGANS. The most convenient method for the removal of the organs of the thorax in older children and in adults is that of Virchow. It is followed here with certain modifications. In infants and young children, and in individuals of any age when important changes are present in the thoracic organs, a variation of the original Zenker technique should be used. (*cf.* Chap. 12.)

The thoracic organs are removed in the following order: heart, left lung, right lung. The thymus has already been removed. The trachea, esophagus, thoracic aorta and the remaining contents of the mediastinum are removed in one piece in connection with the tongue and the throat organs. The thoracic organs may be sectioned while still in the body but greater success will be forthcoming if they are first removed and then sectioned.

Removal of the Heart. The heart is grasped at the apex by the left hand and drawn upward and forward. The great vessels are then severed by horizontal knife strokes from below obliquely upward in the following order: inferior vena cava, left pulmonary veins, pulmonary artery, right pulmonary veins, aorta, superior vena cava. Long stumps are left on the veins so that the auricles will not be injured. Care must be taken to avoid injury to the underlying esophagus, to the trachea and to the hila of the lungs.

Removal of the Lungs. If no reason has been found for retaining the connections between the lungs and the trachea, the lungs are now removed singly. The left lung, removed first, is drawn toward the vertebral column and raised vertically as high as possible by the left hand of the operator. The root of the lung is now held firmly between the first two fingers of the left hand. The lung, resting in the palm of the hand, is drawn

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downward toward the diaphragm, while the knife blade, passing above and behind the fingers of the left hand, makes an incision through the bronchus. When the left hand has raised the lung as far as possible out of the body in a vertical direction, the knife in the right hand cuts the other attachments from above downward. In this procedure the knife is held in a transverse or flat position so that the esophagus and aorta will not be injured. The left pulmonary artery is situated above the left primary bronchus; the right pulmonary artery runs below the right primary bronchus. The method of removal of the right lung is similar to that of the left lung.

Should pleural adhesions be present they are cut before the lungs are removed. When the parietal and visceral pleura are completely adherent the parietal pleura may be stripped from the ribs by means of knife dissection and removed with the lung. Sometimes a small incision through the parietal pleura affords an opening for the fingers of the operator. By means of sweeping movements of the fingers the parietal pleura is then stripped from the ribs. When a portion of the diaphragm is adherent to the base of the lung it should be freed by scissors cuts from its attachment to the ribs and removed with the lungs.

2. REMOVAL OF THE THROAT ORGANS. The organs of the throat are removed in connection with the structures remaining in the thoracic cavity, namely, the aorta, the trachea, the esophagus, and the remnants of the mediastinum. These structures should first be freed from their lateral and posterior attachments to the vertebral column by means of long incisions close to the vertebral column. If the thoracic aorta is not to be removed at this time, it should be freed from all attachments to the remaining structures so that it may be removed with the abdominal aorta after all organs have been taken from the body. In the routine examination, a transverse incision down to the vertebral column just above the diaphragm is now made to divide the esophagus from the stomach and to sever the thoracic portion of the aorta from the abdominal aorta.

Wood blocks are now placed beneath the body between the shoulders so that the head may drop back, thus drawing taut

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the skin over the throat. The skin is then dissected free from the underlying throat organs either by means of a sharp knife or by blunt dissection with curved scissors. When a knife is used, it is placed in a flat position beneath the skin over the larynx (Fig. 7). By means of flat sweeping strokes made from left to right in a gradually increasing lateral and upward arc,

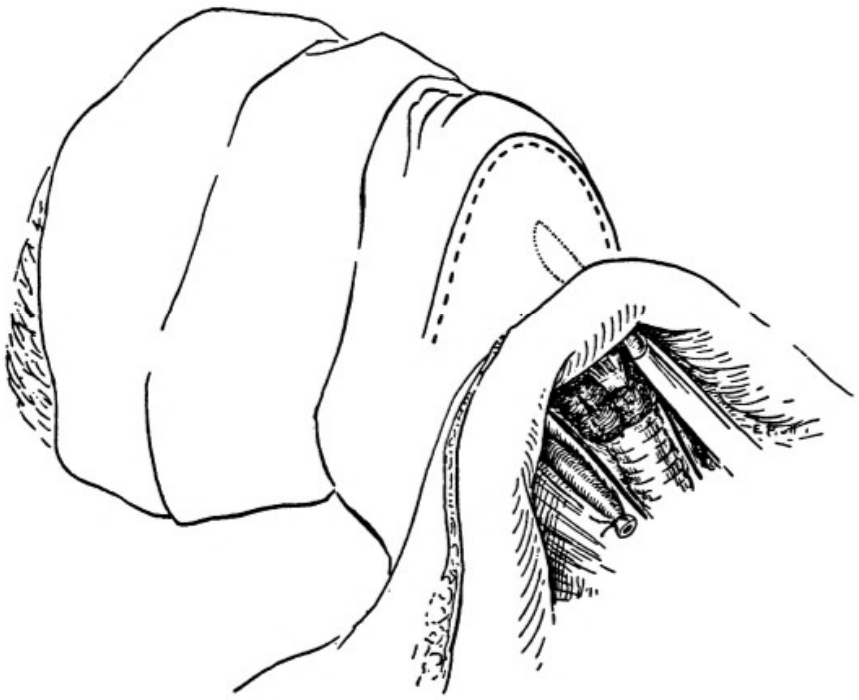

FIG. 7. Removal of the throat organs. The skin over the neck is freed from the underlying throat organs by sweeping strokes made with a knife held in a flat position. The broken line indicates the path of the knife which, carried along the border of the mandible, enters the mouth.

the skin is freed from the underlying structures. Care must be taken that the skin is not incised. The dissection is carried out to a point just lateral to the submaxillary gland on each side and as high as the symphysis of the mandible. Before opening into the mouth the operator should cut the lateral attachments of the throat organs. In this procedure the carotid arteries which have been tied off previously may be used as guides. The incision, passing just medial to the carotid artery on each side and down to the vertebral column, is continued along the lateral borders

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of the vertebral column as high up in the neck as possible. The floor of the mouth may now be entered by the knife-tip, inserted just beneath the mandible in the midline. By means of sawing movements the incision is carried along the mandible as far as the angle of the jaw on the right. The inner border of the mandible is used as a guide for the knife. The position of the knife is then reversed so that the blade faces toward the left.

FIG. 8. Removal of the tongue and the throat organs. The freed tongue is grasped by forceps and pulled downward toward the thorax. The soft palate is separated from the hard palate by short knife incisions.

By means of similar sawing movements the blade is carried along the mandible to the angle of the jaw on the left. The geniohyoglossus muscle is severed by these incisions so that the tongue is now completely free.

The tip of the tongue is grasped by forceps and the tongue is pulled downward toward the thorax. Then the knife, inserted as high as possible on the posterior wall of the pharynx, divides the pharynx. By means of short sawing incisions on either side, continued from the cut into the pharynx, the soft palate is separated from the hard palate (Fig. 8). These last incisions on either side pass laterally as far as possible so that the tonsils

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are included in the removed specimen. With pressure exerted by means of the forceps attached to the tip of the tongue, the tongue is drawn down toward the thorax. All posterior attachments of the pharynx and esophagus to the spinal column and the deep pharyngeal muscles are divided. The tongue and throat organs may now be drawn into the thoracic cavity (Fig. 9).

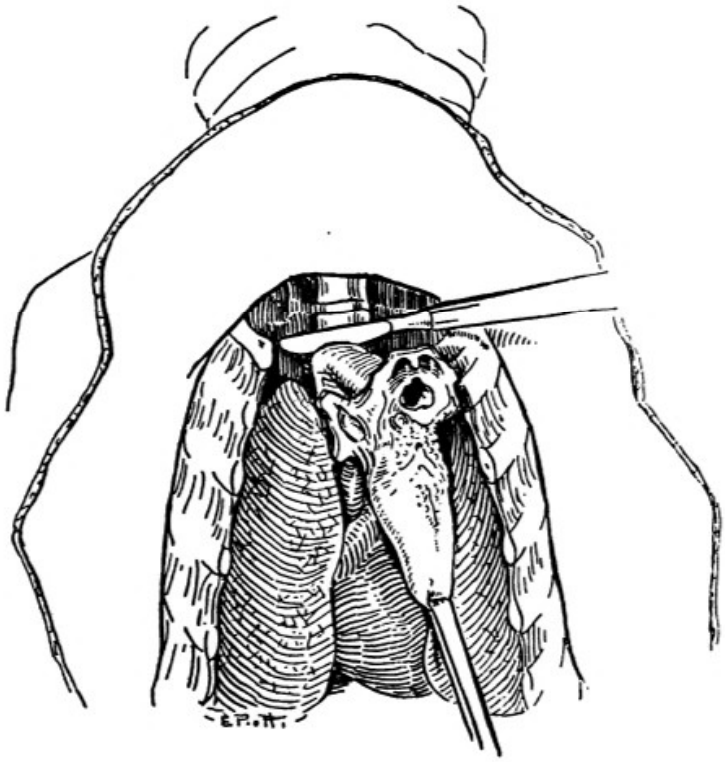

FIG. 9. Removal of the tongue and the throat organs. The tongue and freed throat organs are drawn into the thoracic cavity while all posterior attachments of the pharynx and the esophagus to the spinal column are being divided.

Since the posterior and lateral attachments of the remaining structures in the thoracic cavity have been freed, the complete specimen may be removed from the body. This specimen consists of a portion of the pharynx, the tonsils, esophagus, epiglottis, larynx, trachea, thyroid, parathyroid glands, the first parts of the primary bronchi, the mediastinal lymph nodes, and, when desired, the thoracic aorta.

The submaxillary glands, cervical lymph nodes and parotid

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glands may be removed after the throat organs have been taken from the body. The gland to be removed is grasped by forceps and freed by means of downward traction and blunt dissection around the capsule of the gland. Subcutaneous dissection of the skin over the lower portions of the cheeks is necessary before the parotid glands can be freed. The dissection begins beneath the skin over the mandible, and is continued by flat sweeping strokes of the knife blade to the desired level.

The Stanbury modification of the usual technique for the removal of the tongue and throat organs may be used when the operator desires to simplify the work of the embalmer.[1] The method involves careful dissection and ligation of the larger branches of the carotid arteries during the process of removal of the throat organs. The operator should take particular pains to avoid injuring the external maxillary arteries.

After ties have been placed about the three arteries which arise from the arch of the aorta, the steps outlined above are followed in most details. The skin is reflected upward as far as the ramus of the jaw. The lower end of the trachea, which has been severed at its midportion, is grasped by means of a tenaculum so that the larynx may be depressed as the dissection proceeds. The carotid arteries are then exposed after the sternomastoid and the infra-hyoid muscles have been drawn aside with the aid of blunt retraction. The trachea and the esophagus are now elevated and separated from their attachments to the anterior surface of the cervical spine. Brought into view by this procedure, the inferior thyroid arteries are ligated and severed distally. The dissection is carried upward as far as the upper cornu of the thyroid cartilage. While the carotid arteries are held under slight tension by means of the long ligatures which have been placed about them, the operator opens the carotid sheaths by means of fine scissors. The upper thyroid arteries may now be ligated and severed. It should be noted that the upper laryngeal branch of the upper thyroid artery sometimes arises directly from the external carotid artery. When this anomaly is encountered the upper laryngeal branches must be ligated separately. Stanbury recommends the

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use of a small aneurysm needle in the isolation and ligation of the higher branches of the carotid arteries. The lingual arteries are next ligated and divided. The lingual artery is best located as it forms a loop about the posterior end of the great cornu of the hyoid bone before it proceeds further beneath the hyoglossus muscle. The external maxillary artery is found just above the point of origin of the lingual artery. The external maxillary artery must be left intact since the success of subsequent embalming is dependent upon the retention of the continuity of that vessel. The lingual arteries and the external maxillary arteries sometimes arise by a common trunk from the external carotid artery.

The pharynx is now freed from the anterior surface of the cervical spine as high as possible. The operator should avoid injury to the internal carotid artery since it lies against the lateral wall of the pharynx and to the external maxillary artery since it lies on the constrictor muscles of the pharynx. After the posterior wall of the pharynx has been divided horizontally at about the level of the third cervical vertebra, the larynx and the trachea are returned to their original positions. While the operator depresses the larynx by means of tension on the attached trachea, he passes a long slender amputation knife under the skin to a point just behind the symphysis of the lower jaw. The tongue and organs of the throat are removed according to the instructions given above.

3. REMOVAL OF THE CONTENTS OF THE ABDOMINAL CAVITY. The lateral attachments of the diaphragm on each side are severed by the enterotome. The upward displacement of the structures nearest the thorax permits more space in the abdominal cavity for the necessary operative manipulations. The abdominal contents are most conveniently removed according to their topographic relationships. The spleen, having no important connections, except with its vessels, is removed alone. The intestines are next removed, since they take up considerable space and impede the freeing of other structures. The duodenum, stomach and pancreas, which form the next group of related organs, may be freed with or without the liver from

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their connections in the body. The kidneys, adrenals and ureters, constituting the most posteriorly placed organs, are next removed. There remain but the large vessels and small neighboring lymph and nerve structures. Detailed directions for the removal of the contents of the abdominal cavity follow.

Spleen. Since the pancreas has been previously exposed by the separation of the lesser omentum, the splenic artery and vein which lie in proximity to the pancreas may be viewed after they are freed by slight dissection. When the splenic vein has been opened as far as its junction with the portal vein, a view of the superior mesenteric vein joining the portal vein at the same point, is afforded. The splenic artery is now opened. If no changes are found in the splenic vessels, the spleen may be removed from the body. The operator draws the spleen forward and upward from its bed, and carries a knife incision close to the hilus through the vessels. If fibrous adhesions connect the capsule of the spleen and the overlying diaphragm, the involved portion of the diaphragm is cut away and removed with the spleen.

Intestines. The large intestines, the cecum, and the small intestines as far as the junction of the jejunum and duodenum are now removed from the body. The attachments of the large bowel are freed by means of blunt dissection from the rectum as far as the cecum. Though the attachments are best freed by the fingers of the operator, scissors or a knife may be used when necessary. A little practice will permit the operator to free the entire large bowel from all attachments by means of blunt dissection alone. As soon as two ligatures, spaced five centimeters apart, have been placed around the rectum, this structure is severed. The large intestines, still attached to the small bowel, are now removed from the body, and deposited in a pan placed on the table to the left of the body. The small intestines may now be removed by either of the following procedures.

Method one. The intestines are separated from their mesenteric attachments before they are removed from the body (Fig. 10). This method is recommended when no reason is apparent for retaining the connections of the bowel to the

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mesentery. The first or lowermost loop of ileum is grasped in the left hand and held in such fashion that the mesenteric border presents anteriorly. The left hand, pulling the bowel away from the body of the operator, exerts enough pressure to tauten the mesentery. The mesentery is now separated from the bowel by means of a long knife held in the right hand. The blade is passed lightly back and forth against the

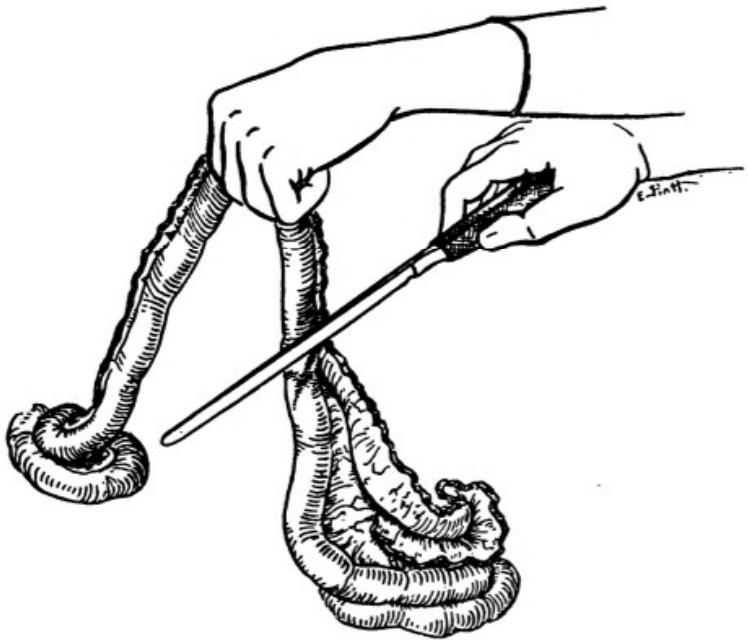

FIG. 10. Removal of the intestines from the body. The intestines, held by the left hand, are separated from the mesentery by long knife incisions carried close to the mesenteric border.

mesentery as close to the mesenteric border of the bowel as is possible without injury to the wall. The motion is much the same as that used in drawing a bow across the strings of a violin. In the meantime, the left hand grasps the next loop of bowel, so that a continuous separation of the mesentery is possible. As the loops of bowel are freed they are deposited into a pan which already contains the large bowel. The bowel must constantly be pulled away from the operator by the left hand. The mesentery is freed from the small bowel as far as the junction of the jejunum with the duodenum. Two

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ligatures spaced approximately five centimeters from one another are then placed around the upper end of the jejunum. These prevent the spilling of fecal material into the peritoneal cavity when the next step, which consists of severing the bowel between the two ligatures, is carried out. The entire gastro-intestinal tract except the duodenum, the stomach and the distal portion of the rectum has now been removed from the body.

Method two. The small intestines and the mesentery are removed together. The mesentery is drawn upward so that the large mesenteric vessels may be viewed. The root of the mesentery is then severed as close as possible to its point of attachment to the floor of the abdominal cavity. The jejunum is ligated and severed as in method one.

Opening the Duodenum in Situ. *Examination of the Bile and Pancreatic Ducts*. The duodenum is opened *in situ* by a scissors incision into its anterior wall at the lower end of the second portion. An enterotome, inserted through this opening, makes a midline longitudinal cut in the anterior wall as far as the pylorus. Now the enterotome, in reversed position, continues the longitudinal incision through the third part of the duodenum to the ligated end of the jejunum. The common bile duct usually opens with the pancreatic duct through the papilla of Vater. The papilla is located on the posterior wall of the second portion of the duodenum at a point just below the level of the middle of the head of the pancreas. The patency of the bile ducts may be tested by both indirect and direct methods. After the contents of the duodenum have been examined for evidences of bile, the common duct is milked of its contents through the papilla of Vater by gentle stroking movements of the fingers. Pressure is then exerted upon the gall bladder to cause the flow of bile into the duodenum through the papilla of Vater.

At times, even though a large amount of bile may be present in the gall bladder no bile will appear in the duodenum after pressure on the gall bladder. This condition is most often caused by a kink in the common bile duct as a result of the

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disarrangement of normal anatomic relationships during the autopsy procedure. If two fingers of the right hand are placed beneath the common duct in order to straighten it, and pressure is then exerted on the gall bladder, bile will often readily appear at the papilla of Vater. If no bile appears after this maneuver, a director is inserted from the papilla of Vater into the common duct, which is then opened by means of fine dissecting scissors for the determination of the cause of the obstruction. A probe may now be passed from the papilla into the pancreatic duct. More careful examination of the pancreatic duct is deferred until the pancreas is sectioned outside the body.

Wolbach recommends a simple procedure for probing the pancreatic duct. First, a probe of large calibre is inserted through the papilla of Vater into the common duct. A second and finer probe, the tip of which has been bent slightly, is then introduced into the papilla for a short distance along the larger probe. The fine probe is thus slipped, usually without difficulty, into the pancreatic duct. The beginner may require a few back and forth manipulations of the fine probe before he passes it successfully into the pancreatic duct.

Liver, Duodenum, Stomach and Pancreas. Two techniques are available for the removal of these organs.

Method one. The duodenum, stomach, pancreas and attached mesentery are removed as one specimen, and the liver is removed subsequently. The diaphragmatic attachments around the stump of the esophagus are first severed. A finger of the left hand is then placed beneath the hepatoduodenal ligament in such a way that the hepatic artery, the common duct and the portal vein, which lie above the finger, are made taut. Each vessel is severed in turn from above downward and inspected further as to its contents. The posterior attachments of the duodenum, pancreas, stomach and mesentery, which are now drawn upward toward the thoracic cavity, are severed carefully from below upward. In carrying out this maneuver, the operator can simplify his work by gathering the structures to be removed between two fingers of the left hand, and at once constricting and tautening all posterior

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attachments. The freed structures are removed from the body.

The liver is now separated from its attachments and removed. First to be severed are, in order, the suspensory, the coronary and the triangular ligaments of the liver. A long flat book incision cuts through the middle of the liver from left to right, but does not completely divide the organ in two. The operator makes this incision *in situ,* in order to facilitate the handling of the liver during removal. He may obtain a firm purchase on the usually slippery organ by placing the thumb of his left hand beneath the liver and inserting the fingers of the same hand in the incision. When the right lower border of the liver has been elevated, it is freed from its attachments with the adrenal below by means of blunt dissection with scissors. The liver is drawn upward and all remaining connections with the body are divided.

Method two. The liver, duodenum, stomach, pancreas and mesentery are removed in one piece. The procedures outlined in the first method are followed in all details, except for the retention of the hepatoduodenal ligament and other connections between the liver and the adjoining structures which are being removed with the liver.

There now remain in the abdominal and pelvic cavities the adrenal glands, the kidneys, the ureters and the pelvic organs. If the thoracic aorta has previously been severed and removed with the thoracic organs, the abdominal aorta and adjacent lymph and nerve structures remain. If this has not been done, the entire aorta is now examined. By means of an enterotome inserted into the upper end of the aorta, a longtitudinal midline incision is carried down beyond the bifurcation of the aorta into the iliac arteries. The renal arteries and adrenal arteries are now opened and examined.

The adrenal glands are next removed from the body. The right adrenal gland has been viewed before the removal of the liver. While the liver is being removed, special care must be taken for the prevention of injury or destruction of the right adrenal. That organ is injured or lost at autopsy more fre-

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quently than any other. By means of blunt dissection with curved scissors it is dissected free from its attachments to the right kidney and removed from the body. The left adrenal is then removed after similar dissection.

Kidneys and Ureters. The ureters are examined *in situ*. If they show no pathologic changes their connections with the kidneys need not be retained. For the removal of the kidneys, the operator has the choice of three methods.

Method one. Remove the kidneys, ureters, abdominal aorta, and pelvic organs in one piece. This method is the simplest for the beginner. It should always be used when pathologic changes are found in the renal vessels or in the ureters. Both kidneys are freed from their beds by blunt dissection performed without instruments. Then the abdominal aorta and all remaining structures are freed from their connections with the vertebral column. The dissection proceeds from above downward to the brim of the pelvis. After the pelvic organs have been freed, all structures may be removed from the body in one piece.

Method two. The kidneys and ureters and the pelvic organs are removed in one piece, without the abdominal aorta. After the renal vessels have been severed, the other organs are removed as in the first method.

Method three. The kidneys are removed singly. This method may be used in the routine autopsy after examination of the renal vessels and ureters has revealed no reason for retaining connections. The left kidney, freed by blunt dissection from the perirenal fat, is drawn vertically upward and toward the midline. The kidney is placed in the palm of the left hand in such a position that the ureter passes between the third and fourth fingers. A firm grasp is assured when the hand is drawn upward so that the ureter is made taut. A single long incision, from the convexity of the kidney through the kidney substance into the pelvis, almost completely halves the kidney. After the capsule has been stripped from the surface of the kidney by means of mouse-toothed forceps, the external surface is viewed. If the ureter appears normal it

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may be severed at a point several centimeters below the pelvis of the kidney. The right kidney is removed and sectioned in a similar fashion.

If dilatation of the ureter and pelvis of one or both kidneys is present, the bladder is best opened *in situ*. If the cause of obstruction is not discovered by this procedure, it may be sought in the posterior urethra. Under such conditions the urethra is removed with the bladder, the other pelvic organs, the ureters and the kidneys, in one piece.

Pelvic Organs. The organs in the pelvis are removed *en masse*. Essentially similar procedures are used for both males and females. The peritoneal coverings of the pelvic organs are stripped from the bony pelvis by blunt dissection executed without instruments. The first fingers of both hands are placed side by side against the symphysis pubis in such a way that the back of the fingers lie against the symphysis and the fingers are directed downward. The fingers are then carried in strong sweeps in opposite directions along the curve of the pubis. The backs of the hands are then placed laterally on the brim of the pelvis so that the palms of the hands are directed toward the posterior attachments of the pelvic organs. The fingers, lifted upward, break all attachments of the pelvic organs with the sacrum. Save for a few peritoneal and vascular connections still present at the brim of the pelvis, attachments now remain only at the urethra and at the rectum. A Kelly clamp is placed on the upper cut end of the rectum and another is attached to the dome of the bladder. Both clamps are held in the left hand, which exerts pressure upward to draw both the bladder and the rectum together and to make all attachments taut. The knife blade is then inserted against the symphysis and directed obliquely forward. In the male the urethra and the first portion of the corpus cavernosum of the penis and in the female the wall of the vagina and the urethra, are severed in this procedure. When the rectum and the bladder have been drawn toward the symphysis by means of the attached clamps, knife incisions executed posteriorly in the floor of the pelvis, free all remaining peritoneal and vascular connections. In this pro-

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cedure the ureters, if still attached to the kidneys, are not injured. To sever the rectum, the operator directs the handle of the knife perpendicularly to the promontory. The freed pelvic organs may now be removed from the body.

Removal of the Male Genitalia. The testicles are removed without external injury to the scrotum. The scrotum may be entered by a small incision beneath the skin over the pubis on each side, or by means of blunt dissection through the inguinal ring. The testicle, epididymis, and attached spermatic cord are forced upward into the pelvic cavity through the inguinal ring or through the incision which has been made beneath the skin over the pubis. The overlying tissues are cut through until the tunica vaginalis is reached and severed. As soon as the spermatic cord has been severed on each side, the testes, epididymides and attached cords are removed.

When it is desirable to remove the penis with the bladder, prostate, ureters, and kidneys, the penis is dissected free from the overlying skin before the pelvic organs are removed. A V-shaped section of bone is removed from the symphysis pubis or an incision may be carried through the cartilaginous portion of the symphysis. The penis is separated from its connections beneath the symphysis by means of semicircular knife incisions which are carried as far as the angle of the pubis. The knife blade, inserted beneath the skin overlying the penis, breaks all connections with the skin. The penis, which is then severed a few centimeters above the glans, may now be drawn into the pelvis. After the testes and spermatic cords have been freed by the method described above, all portions of the external genitalia may be removed in one piece with the pelvic organs and, if desired, with the ureters and kidneys.

According to the method of Cattell for the removal of the male genitalia, the penis is grasped with the left hand and drawn upward and backward over the symphysis pubis so that the scrotum and the under surface of the penis come into view.[2] A fold of skin is then lifted at the point where the integument of the penis merges into that of the scrotum. The skin at this point is drawn taut and incised in a line perpendicular to the

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long axis of the penis. An oval gap approximately four centimeters in diameter discloses itself when the fold of skin is permitted to fall back. This opening is large enough to permit the removal of the contents of the scrotum and yet so small and so well placed that, after the wall has been sewed, the line of incision will be entirely concealed when the penis is returned to its normal position. The first finger of the right hand is introduced into the scrotum through the opening just made and swept around so that the delicate areolar connective tissue which forms the septum of the scrotum is broken. The testicles can be forced one at a time into the dilated external opening and removed from the scrotal sac.

The root of the penis is then grasped from within and the loose bands of connective tissue which unite the body of the penis to the overlying skin are broken by sweeping strokes of the finger. The body of the penis is now drawn from its connective tissue sheath as far as the point of union of the prepuce with the tissues at the collum. The glans is then amputated at a point about one centimeter above the corona by means of a scissors cut. During this procedure the body of the penis is supported between the thumb and first finger of the left hand.

Examination and Removal of the Abdominal Aorta and Femoral Vessels. The abdominal aorta (and the thoracic portion, if it has not been removed previously) has been opened *in situ* before the removal of the adrenals and the kidneys. The intimal surface of the aorta is now examined for evidences of atheromatosis, aortitis (in the thoracic portion), dilatation and aneurysms. The elasticity of the aorta is then tested. A transverse incision is rapidly made across the opened aorta at a convenient level down to the vertebral column. The distance between the cut ends of the aorta is then measured. This should vary normally from five to eight centimeters.

The femoral vessels may now be examined, by means of prolongations of the primary skin incision on each side along the femoral canal, to expose the artery which lies in the middle, the vein which is placed medial to the artery and the nerve which is lateral to the artery. The vessels to the legs may be opened as

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far as is indicated in the particular case. The aorta is then freed from all connections with the vertebral column by means of short strokes with the cartilage knife, and removed with the adjacent retroperitoneal lymph nodes and adherent tissue of the abdominal sympathetic nervous system.

If the operator prefers to open the aorta after removal from the body, the technique of Orth may be used. The first finger of the left hand is inserted as far as possible into the upper end of the aorta. By the traction so obtained, the aorta is drawn upward and then downward as the posterior connections with the vertebral column are severed.

Examination of the Thoracic Duct. The thoracic duct may be opened by fine dissecting scissors. Its lumen varies from three to eight millimeters in calibre. The dissection is best begun at the cisterna or receptaculum chyli, which is a triangular dilatation situated on the body of the second or the third lumbar vertebra to the right and behind the aorta. The duct, which may be followed upward through the aortic hiatus of the diaphragm, is found most easily by blunt dissection into the connective tissue to the right of the vertebral column between the aorta and the azygos vein. The duct then crosses to the left, rises to the neck and returns to enter the left subclavian vein at its point of junction with the left internal jugular vein. The thoracic duct may be examined before the lungs are removed. For this procedure, the right lung is drawn toward the left pleural cavity to reveal the duct adjacent to the vertebral column. The right lymphatic duct, of little importance in most autopsies, enters the right subclavian vein.

Examination of the Inferior Vena Cava and Its Tributary Veins. The vein, which lies to the right of the abdominal aorta, is opened by a midline scissors cut beginning at the point where the vein has been severed in the removal of the liver. The incision is carried down into the common iliac veins and as far into the external iliac, hypogastric, femoral and other tributary veins as is indicated. The adrenal and the renal veins are investigated before the adrenal glands and the kidneys are removed. The right adrenal vein opens directly into the inferior

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vena cava; the left joins with the left renal vein or the left inferior phrenic vein. The spermatic veins, or the ovarian and uterine veins are opened prior to the removal of the pelvic organs. The ovarian and uterine veins are dissected with great care in autopsies on pregnant or recently delivered women. The inferior vena cava may be removed from the body after the removal of the aorta.

Removal of the Diaphragm and Examination of the Psoas Muscle. The diaphragm, which has been lacerated in the removal of the abdominal organs, is now freed from all remaining connections by knife strokes, and removed. Several longitudinal and transverse incisions are made in each psoas muscle for the detection of possible abscesses or foci of tuberculosis. This procedure is of particular importance in instances of tuberculosis of the vertebral column.

Removal of Lymph Nodes. Representative specimens of lymph nodes are removed for further study in every autopsy. Particular attention is paid to lymph nodes in the cervical, axillary and inguinal regions. Lymph nodes in other regions of the body (mesentery, mediastinum, etc.) are removed and sectioned when the adjoining structures are sectioned.

REFERENCES

1. Stanbury, W. Stuart: A Simple Postmortem Technique for the Removal of the Organs of the Neck, J. Tech. Methods 15, **42**, 1936.
2. Cattell, Henry W.: Postmortem Pathology, Second Edition, Philadelphia, J. B. Lippincott Company, 1905.

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CHAPTER VII

THE CRANIAL VAULT AND THE SPINAL CORD

1. REMOVAL OF THE CALVARIUM. An examination of the scalp is first made for wounds or unusual marks or parasites. Before the scalp is incised the head is placed on a head holder, or on a wooden block. If the head, while resting on a wooden block,

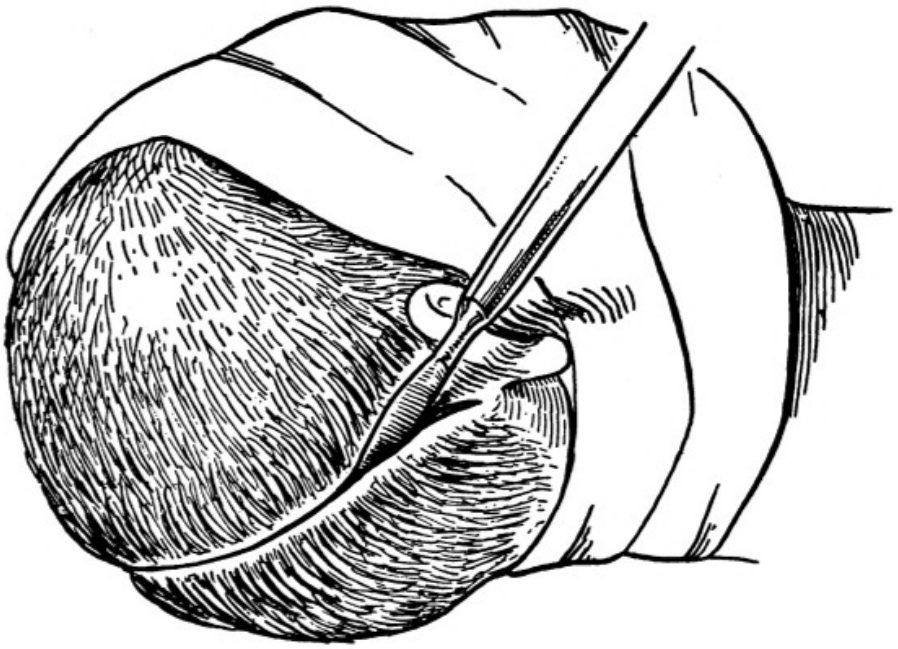

FIG. 11. Incision into the scalp. The scalpel with upturned blade is carried from a point behind the right ear over the vertex of the skull. The hair has been combed and parted in the line of the scalp incision.

extends over the edge of the table, a suitable receptacle to collect blood and fluid should be available on the floor beneath the head. The hair is combed and parted in the line of the skin incision which, semicircular in form, is made with the cartilage knife or a sharp scalpel from the right to the left mastoid process. If there is a large amount of hair the incision passes over the vertex of the skull. If hair is sparse the incision is made low and directed over the occipital protuberance. The upturned

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blade of the scalpel is inserted into the skin over the mastoid process at a point about one centimeter behind the ear (Fig. 11). The hair is thus parted by the blade and not cut when the scalp is incised. The scalp is reflected over the calvarium and drawn forward over the face. Adhesions to the cranium are present in the posterior segment more often than in the anterior. When such adhesions are found, the scalp is dissected free from the calvarium by means of light sweeping strokes of the knife or by blunt dissection carried out with a raspatory or the end of the scalpel handle. The periosteum is then scraped off the calvarium with the handle of the knife or the blade of a chisel. The cut ends of the temporal muscles, now incised in their mid-portions, are saved for later reconstruction of the skull. For the beginner it is advisable to mark the line of the saw-cut by means of a colored pencil or scalpel. The saw incision may be made with the flat fox-tail saw or with an electrically driven revolving saw. The latter is found to be particularly useful in large institutes of pathology.

The calvarium is held firmly by the Bigelow head holder which is so placed that the blade of the saw is always parallel to the long axis of the head holder. When no holder is available a towel wrapped about the left hand may serve as a substitute. Two methods of opening the skull by means of saw cuts are in common use. The first is called the *angular* or *wedge-shaped* method and the second the *circular* method.

The *angular* method is more difficult for the beginner but gives better results in the reconstruction of the skull. The calvarium is sawed in two planes which intersect so as to form an obtuse angle at a point a little below and slightly posterior to the apex of the ear (Fig. 12). To prevent disfiguring marks after reconstruction the operator should begin the anterior incision a little above the level of the hair line. In making the saw cut which goes from behind the ear to the junction of the sagittal and the lambdoid sutures (the lambda), the operator tilts the saw toward the vertex of the skull. The resulting line of incision has a beveled surface which helps to keep the calvarium in place when the skull and scalp are restored. The

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anterior saw incision may be carried out in a similar manner so that the entire saw incision will have a beveled surface. In making the anterior saw incision, the operator tilts the saw toward the vertex again. The bevel in this case slants in a direction opposite to the bevel of the posterior incision. A good rule for the operator to follow when making the saw incision is to keep the saw tilted slightly toward the vertex of the skull. It is some-

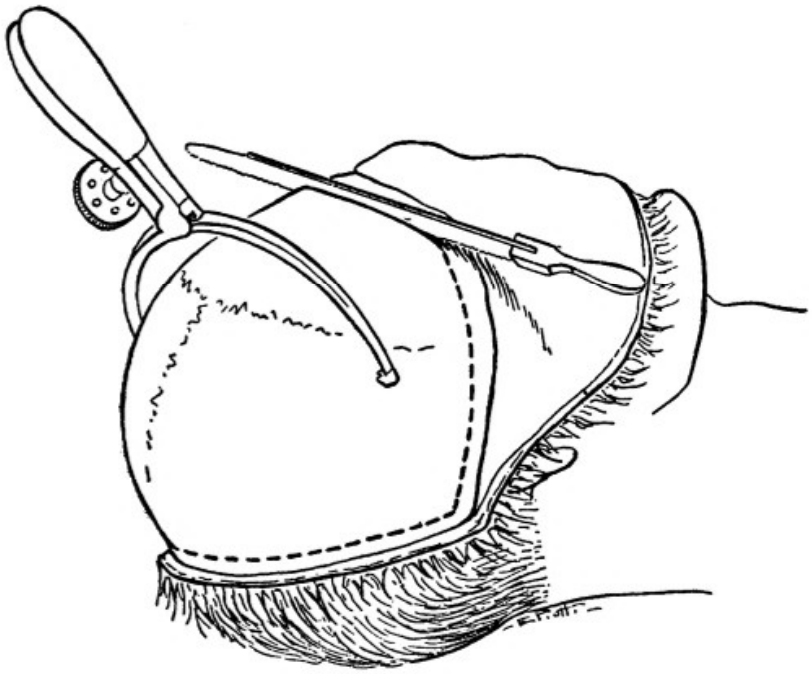

FIG. 12. Angular method for removal of the calvarium. The scalp has been reflected over the face. The calvarium is held by means of the Bigelow head holder. The broken line marks the path of the saw cut through the calvarium. The calvarium is sawed in two planes which intersect so as to form an obtuse angle at a point a little below and slightly posterior to the apex of the ear.

times helpful to leave a triangular projection in the squamous portion of the occipital bone to give further support to the calvarium when it is replaced after the autopsy.

A wider exposure of the brain is afforded by the use of the original *wedge-shaped* incision in the removal of the calvarium. This method necessitates three separate saw cuts, the paths of which are marked out on the calvarium by a scalpel or a pencil before the saw cuts are made. The first cut begins just

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behind the left ear at a point *four centimeters* above the external auditory canal. It is carried over the frontal bones in a line *two centimeters* above the supraorbital ridge to a point *four centimeters* above the external auditory canal on the right.

The two remaining saw incisions begin at the ends of the first saw cut and meet in the midline at the occipital protuberance at an angle of about one hundred and sixty degrees. An obtuse angle is formed behind each ear by the intersection of the first saw cut with each posterior incision. The Bigelow head holder is then fastened to the calvarium in such a way that one foot rests in each obtuse angle. In the reconstruction of the skull, special attention is paid to the appearance of the forehead. After the calvarium has been set in place, the defect made in the skull by the saw cuts is filled with dry bar soap. This procedure assures a smooth skin surface over the frontal bones when the scalp is pulled back over the calvarium.

The *circular* method of opening the skull is also widely used. An incision beginning about three centimeters above the supraorbital ridge, is made horizontally in the skull and continued in straight lines on both sides to the occiput where both lateral cuts meet.

The saw cuts are carried through the outer table and partially through the inner table, but not into the dura. Some pathologists prefer to stop the incision after it has penetrated the outer table. The inner table of the skull is successfully sprung apart by the small transverse chisel of Virchow which is inserted in the saw line at three or four points and quickly rotated (Fig. 13). The frontal portion of the calvarium is then grasped by the fingers, which are protected by a towel or by the hook on the end of the steel hammer, and is completely torn from the dura by a strong backward pull. In children and in elderly subjects the dura is often adherent to the calvarium. A spoon (a long flat rectangular steel instrument) or a closed enterotome may be used to separate such adhesions. When this is not possible, the dura must be removed with the calvarium. As soon as the attachments of the falx in the midline have been severed posteriorly and anteriorly, the calvarium with the dura attached is removed

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by a strong backward pull on the calvarium. After removal of the calvarium its thickness and its permeability to light are noted. Descriptions are now made of the inner surface of the calvarium, the pacchionian depressions and the furrows of the meningeal arteries. Hereupon follows the viewing of the dura

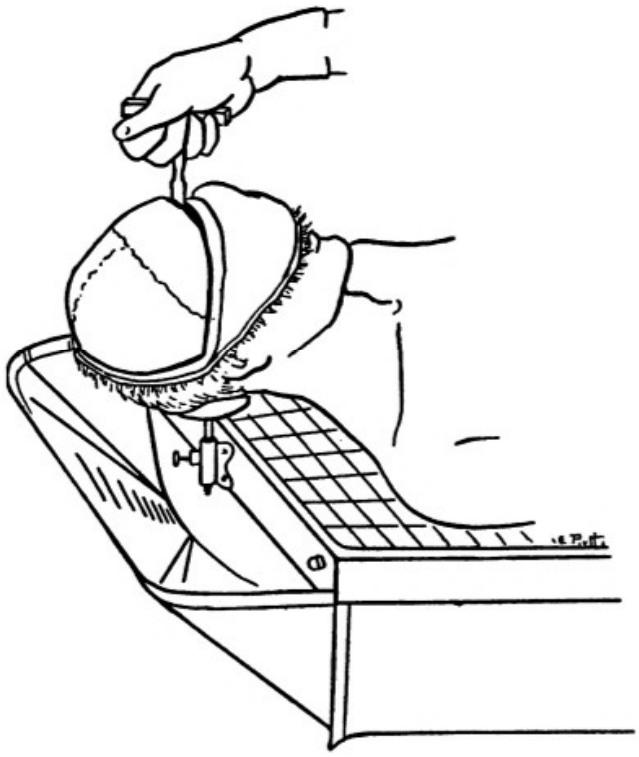

FIG. 13. Removal of the calvarium. The saw cuts have been carried through the outer table and partially through the inner table. The transverse chisel of Virchow is inserted into the saw line and rotated quickly in order to spring apart the inner table of the skull. Note the special head holder and the drip pan.

through which structure the brain may be palpated. A successful removal of the calvarium is judged by the intact condition of the dura.

2. REMOVAL OF THE BRAIN. The longitudinal sinus is now opened from back to front with the upturned knife blade (Fig. 14). If a thrombus is found on inspection of the contents, special care must be taken to maintain the continuity of the venous

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sinuses during the later operative maneuvers in the skull. A small scissors cut is now made cautiously in the dura at the saw line on the right side and continued until the right half of the dura has been incised along the entire saw line (Fig. 14). The structure is then lifted carefully by forceps and reflected over the left hemisphere. After inspection of the inner surface of

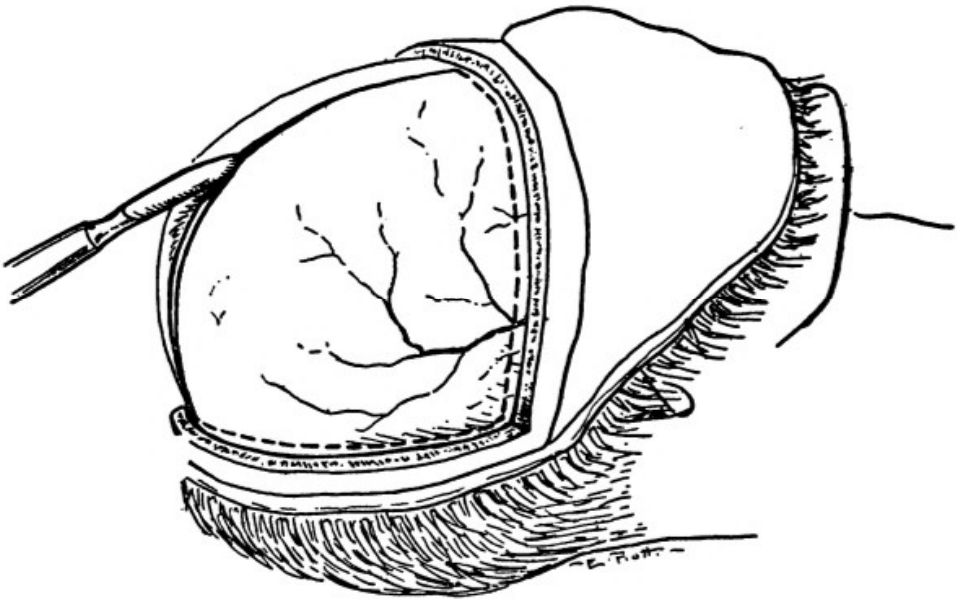

FIG. 14. Opening of the longitudinal sinus. The calvarium has been removed. The sinus is opened by means of a scalpel with upturned blade. The broken line indicates the path of the incision into the dura.

the dura, the meninges and the convexity of the brain, this flap of the dura is returned to its original position. A similar procedure is carried out on the left side. The inner surface of the dura is inspected with reference to smoothness, color, moistness, pacchionian granulations and the presence of hematomata or other pathologic processes.

Before any further dissection is carried out an examination of the falx and of both leaves of the tentorium is made. The handle of the scalpel is inserted between the falx and the right cerebral hemisphere, which is drawn lightly to the right. The left cerebral hemisphere is treated in similar fashion. This procedure not only yields a good view of the falx but also facilitates

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the later removal of the brain, since the connections between the falx and the cerebrum are thus broken. Turning the skull to the left, the operator lifts the tip of the temporal lobe on the right gently to reveal the tentorium on that side. The skull is then tipped toward the right for a similar examination on the left side.

In the subsequent removal of the dura, both halves of the structure are drawn together by the left hand and pulled vertically upward. As soon as the insertion of the falx at the crista galli has been cut by the scalpel, the dura is drawn in turn upward, backward and downward by means of a steady pull which separates it from its connection with the meninges along the longitudinal sinus. It is permitted to hang over the occipital bone, still attached to the dura covering the base of the skull.

In removing the brain, the operator raises the frontal lobes gently with the fingers of his left hand, and draws the lobes toward him. Holding the scalpel like a pen, he cuts the olfactory nerves at their attachment in the cribiform plate of the ethmoid bone. Then follows division of the various nerves and vessels, which are severed as near as possible to their foramina so that long stumps remain attached to the brain. In this procedure the tip of the scalpel is always pointed toward the bone. The optic nerve, first on the left and then on the right, and the carotid arteries are cut. The carotid arteries are cut in such a way that long stumps are left in the base of the cranial vault. The cut ends are ligated after the brain has been removed. The various cranial nerves are then cut in order, first on one side and then on the other while the brain, constantly supported by the left hand, is allowed to sink slowly backward. Finally, as the temporosphenoidal lobe of the brain leaves the middle fossa of the skull, the tentorium is divided so that the cerebellum may be removed with the cerebral hemispheres. The brain is drawn to the opposite side during the incision of the tentorium, first on the left and then on the right, by means of short knife cuts. The incision travels along the superior border of the petrous portion of the temporal bone, but spares the cerebellum from injury.

Now that the tentorium on each side is cut, the brain is

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allowed to sink backward supported by the left hand. It must not be torn away from the cerebellum or the brain stem. Since any remaining nerves which arise from the brain stem are severed at this time, only the spinal cord now connects the brain with the body. The spinal cord is severed transversely by the Chiari myelotome which is inserted into the foramen magnum as far as possible. While the cerebrum is supported in the left hand, the freed brain is removed from the body.

3. THE BASE OF THE SKULL.

Opening of the Venous Sinuses. The longitudinal sinus has been opened before the dura was reflected. The sinuses in the base of the skull are first palpated gently for evidence of thrombosis. If thrombi are present it is best to strip the dura, in which the sinuses lie, from the base of the skull. The sinuses are then opened outside the body by means of short scalpel cuts which, lifting wedge-shaped pieces from the roof of the vessels, reveal the thrombi. If no thrombi are present the venous sinuses of the skull are opened by longitudinal midline scissors or knife incisions which begin at the confluence of the sinuses (torcular Herophili). After the transverse (lateral) sinus, the sigmoid, the inferior petrosal, the cavernous, the superior petrosal, the circular, the occipital and the straight sinuses have been opened in turn, the continuation of the sigmoid sinus into the internal jugular vein is explored.

The dura which has been removed from the convexity of the brain and is still attached in the midline at the occipital protuberance, is now removed in continuity with the dura which covers the base of the skull. The latter structure, freed by means of a forceful pull or blunt dissection or short knife cuts, is finally severed at the foramen magnum and in the sella turcica. The base of the skull may now be examined for evidences of fractures or other pathologic changes.

Examination of the Ears. The middle ears are exposed by one of several methods.

Method one. The old method employs a chisel by which the roof of the middle ear on each side is removed. The roof lies in the middle of the petrous portion of the temporal bone.

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Method two. The most convenient method makes use of the heavy bone forceps of Councilman (*cf.* Fig. 1b). Each petrous portion of the temporal bone is crushed by the forceps in two places. The blades first grasp the pyramid of the

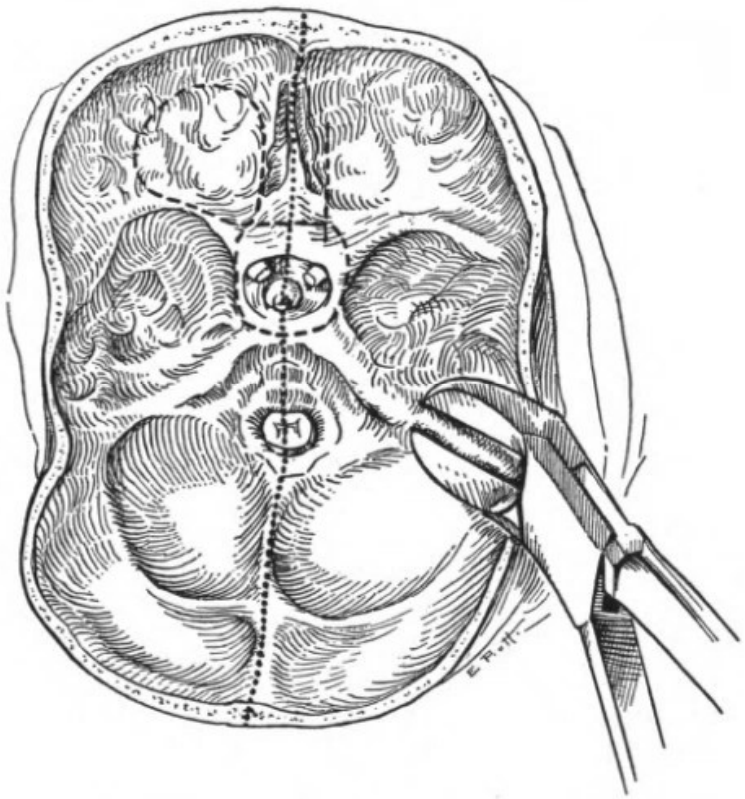

FIG. 15. The base of the skull. The calvarium has been removed by the angular method. The illustration shows the position of the Councilman forceps used in exposing the middle ear. The dotted line which passes through the midline of the skull indicates the path of the saw incision according to the method of Harke for the exposure of the air sinuses. The broken line shows the locations of chisel cuts made to expose the eye and the air sinuses of the skull.

petrous bone on the right side of the skull at a point just external to the arcuate eminence, which forms the roof over the superior semicircular canal (Fig. 15). When the blades are brought together, the bone is crushed transversely and is cracked in irregular longitudinal lines on each side of the pyramid. The medial incision is made near the junction of

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the internal and middle thirds of the petrous bone at the level of the jugular foramen and of the internal acoustic meatus. After the medial forceps incision has been made, the portion of the bone between the two incisions is grasped by the forceps and torn from the skull by quick twisting movements. The ear drum and the malleus are now seen in the base of the skull; the incus and the stapes are attached to the removed portion of the petrous bone. The ear drum on the left is then exposed in a similar manner. The mastoid cells may be exposed by chisel strokes or by further cuts of the large bone forceps. The Eustachian tube may be probed from its point of exit in the anterior portion of the tympanic cavity.

Method three. Method three is used in instances when the entire middle ear and the external auditory meatus are to be examined. The incision behind the ear which was made to prepare the scalp for reflection is carried back along the anterior border of the trapezius muscle about half way down the neck. The skin flaps which include the external ears and the underlying tissues are dissected away from the bone on each side. A wedge-shaped piece of temporal bone is sawed out by means of two cuts which go through the temporal bone and meet in the clivus of the sphenoid bone. The anterior cut passes through the root of the zygomatic arch; the posterior cut passes just behind the sigmoid sinus in order to include the sinus in the removed specimen. The petrous bone, freed now from the skull by means of chisel and mallet, is removed. The specimen is examined immediately, or is fixed in formalin for subsequent decalcification and microscopic study.

The operator may obtain a view of the middle ear by chiseling off the roof of the tympanic cavity. He then cuts away the lower wall of the external auditory meatus to expose the external surface of the tympanic membrane. The petrous bone is divided by a hand jigsaw in a line parallel to the crest of the pyramid of the petrous bone. The cut, which begins at the styloid process and emerges at the carotid canal, thus divides the tympanic cavity in two. The tympanic membrane, the malleus and the anterior half of the mastoid

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cells are discovered in the lateral position. In the median portion are found the labyrinthine wall of the middle ear, the stapes and the posterior half of the mastoid cells.

Removal of the Pituitary Gland. The pituitary is lifted gently from its bed on the floor of the sella turcica. Blunt dissection beginning at the posterior clinoid process is continued beneath, around, and above the pituitary gland.

Exposure of the Eyes. An irregular portion of the orbital plate of the frontal bone is broken through by chisel strokes (Fig. 15). After the cuts have been carried well outside the exposed portion of the optic nerve in the base of the skull, the capsule of Tenon and the fat pad usually found beneath the orbital plate are removed. By means of cuts with sharp scissors the eye ball is freed while the sclera is held with forceps. The posterior half of the eye is then removed by an equatorial cut made quickly with scissors, which pass through the sclera posterior to the conjunctival attachment. A piece of cotton dipped in India ink is inserted in place of the posterior half of the eye to disguise any external evidence of the removal.

Exposure of the Air Sinuses of the Skull. The operator has the choice of several techniques (Fig. 15).

Method one. A broad chisel, placed vertically on the base of the skull close to the entrance of the optic nerves in the optic foramen, is driven to a depth of about one and one-half centimeters to expose the frontal sinuses. For the removal of the floor of the sella turcica the chisel is forced horizontally into the right side under the floor. By similar chiseling both sphenoidal sinuses may be opened wide. The lateral margins of the lamina cribrosa are cut perpendicularly to expose the ethmoid sinuses. By means of a strong pull downward and outward with bone forceps or by further chiseling in the same direction the maxillary antra (Highmore) may now be exposed.

Method two. According to *Harke's* method for exposing the nasopharynx and the air sinuses of the skull, the skin is dissected downward and forward over the frontal bone to the

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supraorbital ridges, and pulled down over the face as far as possible.[1] Similar dissection is performed posteriorly to free the skin to the occipital foramen and the upper part of the cervical vertebrae. After the external auditory meatus has been severed subcutaneously, the skin is dissected down to the zygomatic arch. The skull is raised by means of a large block or a head holder, so that the head is flexed on the body. A sagittal saw incision, carried through the entire base of the skull and the cervical vertebrae, divides in turn the occipital and frontal bones, the sella turcica, the cribiform plate and the basilar process (Fig. 15). The operator must guard against carrying the saw cut too far anteriorly and thus injuring the skin over the nose.

If more room is desired, the atlas and axis are sawed through. The skull is then halved by means of forceful lateral traction on each side. In this process the nasal bones, the hard palate and the alveolar process of the upper jaw are broken. Any persisting connections are cut or chiseled. After the walls of the air sinuses of the skull have been removed from the cut surfaces by bone scissors, a good view is afforded of the sphenoid and frontal sinuses, the nasal septum and the nasal passages. The maxillary antra may be readily exposed by bone scissors. The two portions of the skull are now brought together and held securely in place by means of wire or string sutures which pass through drill holes bored for this purpose. No evidence of the operation should be apparent after the body has been reconstructed.

Method three. By means of a core drill or trephine, recently described by Dunn and Rhea, exposure of the accessory nasal sinuses, the nasal passages, the mouth and the pharynx may be obtained from the base of the skull.[2] After the calvarium, brain and pituitary gland have been removed and the dura stripped from the base of the skull the core drill may be applied. Constructed of seamless steel tubing, the saw part of the drill has coarse teeth which number six to eight to the inch. The tubing, approximately eleven centimeters in length, is attached to a holder similar to the type

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used for carpenters' drills. A center drill projects beyond the teeth of the saw at the end of the metal tubing so that the saw may be steadied at the beginning of the cut. The center drill is placed in the pituitary fossa and the core drill is pointed in a mid-sagittal plane toward a point between the tip and the angle of the mandible. If the core drill is pointed too far posteriorly the anterior cervical ligaments will be met and thus cause obstruction. The operator should locate the axis of cutting in the mid-sagittal plane, so that the drill will not strike the teeth of the patient. The drill chatters for a few revolutions and then takes hold smoothly. After a number of turns the operator, feeling that the drill is cutting soft tissue, removes the instrument. The remaining core is freed from the surrounding soft tissue by a short thin-bladed knife. The maxillary sinus, the tongue and the tonsils may be examined from above through the opening provided by the removal of the core. If the base of the tongue is depressed the lower pharynx, epiglottis and larynx come into view.

The removed core of tissue is now divided in a mid-sagittal plane. The posterior ethmoid and the sphenoid sinuses, the posterior portions of the turbinates, the nasal septum and the palate are hereupon brought into view. The anterior ethmoid and the frontal sinuses are not contained in the removed specimen but may be exposed by chiseling from the surface of the operative defect in the base of the skull.

Exposure of the Nasal Orifices, the Choanae and the Laryngeal Vestibule by the Method of von Hansemann.[3] After dissecting the scalp posteriorly, the operator frees the soft parts as far as the occipital foramen. Then he may sever the articular ligaments between the occiput and the atlas, and divide the spinal cord. The skull is now pressed forcefully forward and luxated on the body. A dividing incision into the posterior musculature of the pharynx affords a wide view of the choanae, the nasopharynx, the laryngeal vestibule and the base of the tongue.

4. REMOVAL OF THE SPINAL CORD. The spinal cord may be removed either anteriorly or posteriorly. When it is removed

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anteriorly the bodies of the vertebrae are freed and removed to expose the spinal cord, after the contents of the thoracic and abdominal cavities have been taken from the body. The anterior approach (described in Chapter 10) is preferable in autopsies on small children but is not to be recommended in examinations on older individuals. In the procedure of posterior approach, the cord may be removed either before or after the examination and removal of the viscera. The advantage of removing the cord before the viscera is that of a cleaner performance, since the skin over the chest and abdomen is still intact.

Now the body is rolled over on the table in prone position and a block is placed beneath the thorax. A midline incision with a cartilage knife begins at the occipital protuberance (or at a point several centimeters below, if the entire cord is not to be removed) and is carried down over the spinous processes of the vertebrae to a point between the third and fourth lumbar vertebrae. The skin, muscles and soft tissues are dissected away bilaterally and all soft parts are freed from the laminae. A vertebral groove on either side of the spinous processes is thus exposed. The laminae, which may be incised by the ordinary flat saw or by Luer's rachiotome, a double bladed saw, are divided as close as possible to the transverse processes, from the third or fourth lumbar vertebra to the cervical region. The arches of the atlas and axis are best cut with bone forceps. The operator will know, by the mobility of the spinous processes, whether his saw cuts have been carried deep enough. Having made a transverse incision between the third and fourth lumbar vertebrae, the operator grasps the lumbar end of the freed spinous processes with the bone forceps, and by means of a strong pull upward, tears off the spinous processes in one piece as far as the occiput (Fig. 16). The cord surrounded by dura may now be viewed. The dura is lifted carefully by forceps and drawn to one side, and thereupon the extradural nerves are severed. A similar procedure is carried out on the other side. The operator now divides transversely the dura and the nerve roots at the lower end of the spinal canal, and, holding the dura with the forceps, raises the cord carefully and severs all remaining connections.

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The cord must not be squeezed or torn during this procedure. Projecting bony prongs of the spinous processes should be

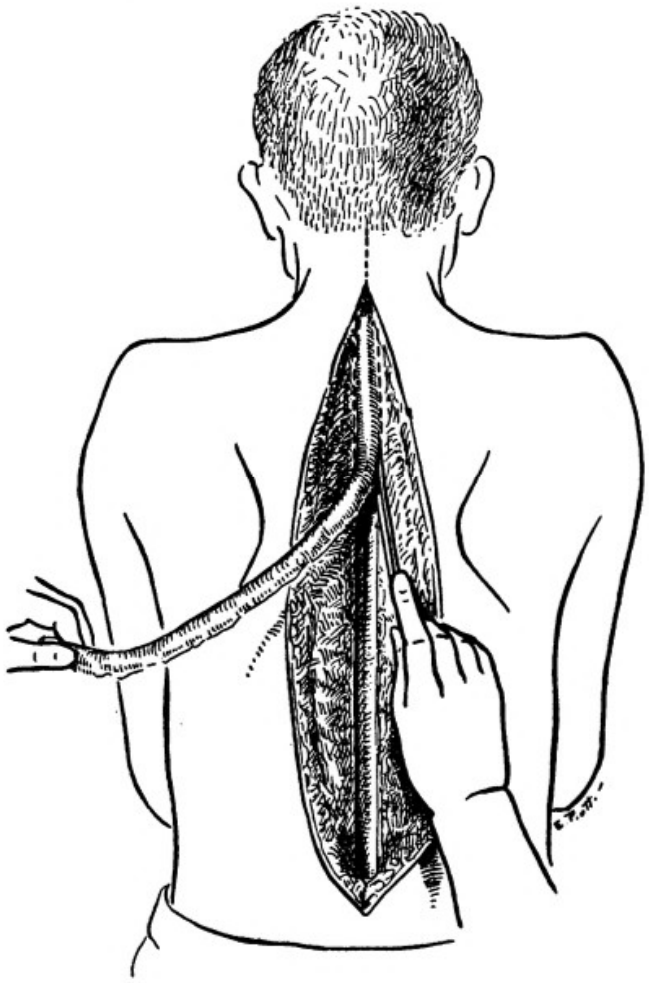

FIG. 16. Removal of the spinal cord in postmortem examinations on adults. The spinous processes have been removed. The cord, still covered by dura, is separated from all connections from below upward. If desired, the skin incision may be continued upward as far as the occiput.

removed with the bone forceps before the cord is finally removed from its canal.

At this point, a choice of two procedures presents itself. In the usual case the dura and cord are divided transversely as near to the occipital foramen as possible. The freed cord surrounded

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by its dura is then removed from the spinal canal. In cases of pathologic changes in the cord and the brain, when those structures should be removed in one piece, the cord is freed in the usual manner. The dura is opened by a midline incision, and all connections between the dura and the cord are severed. The brain is then exposed and disengaged from all connections except those with the cord. As the brain, still attached to the cord, is lifted from the skull, the cord is drawn through the foramen magnum.

5. SECTION OF THE SPINAL CORD. The cord, still enclosed in its dural sac, is stretched out on the platter. The dura is then opened by a midline longitudinal scissors cut. The lower blade of the scissors lifts the dura as the cut is being made. Now the lateral leaves of the opened dura are flattened so that the cord may be viewed. The external appearance of the cord is noted and the meninges are inspected. By means of a long sharp knife which is first dipped into water to prevent the cord from sticking to the blade, the cord is sectioned at intervals of four to five millimeters by a series of transverse incisions which pass through the cord but not through the dura beneath. The operator then lifts the upper end of the cord and places it over the fingers of his left hand. Grasping the dura with mouse-toothed forceps or in the fingers of his right hand, he draws the dura with the cord still attached slowly over the fingers of his left hand. In this way each cut surface of the cord, falling over the ends of his fingers, comes into view. The size and shape of the various portions of the cut surface of the cord are inspected. Then the size of the central canal is measured. All abnormal openings or areas of softening are measured and described. A note is made of sharpness of the line of demarcation between the white and gray matter, and of possible eversion of the cut edges. Under usual conditions the white matter projects slightly on the cut surface of the cord. Representative sections are chosen from various levels and placed in suitable fixatives. The diameter of the cervical portion of the cord measures approximately fourteen millimeters, the dorsal portion ten millimeters and the lumbar portion twelve millimeters.

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6. SECTION OF THE BRAIN.

External Examination of the Brain. The brain is weighed and all external surfaces are inspected. Note is made of the consistency and thickness of the meninges, the color, character, and amount of the fluid in the subarachnoid space, the presence and distribution of exudate, the contour of the convolutions and the depth of the sulci, the appearance of the superficial meningeal vessels, and the presence of any deviations from the normal. The consistency of the brain is determined by palpation on all surfaces. Each convolution, palpated by the ball of the little finger of the right hand, is compared to all other convolutions. The vessels at the base of the brain are examined carefully and dissected. Because they are a frequent seat of cerebral emboli, the branches of the middle cerebral artery are followed in the fissure of Sylvius with particular attention. At the base of the cerebellum is sought evidence of a pressure cone. This condition, resulting from herniation of the cerebellum into the foramen magnum is found in cases of increased intracranial pressure and is manifested by a deep impression into the cerebellar substance corresponding to the position and shape of the foramen magnum. Great care must be exercised in handling the brain, which tears on very slight trauma. The cut end of the cervical cord is inspected for evidence of edema, most often manifested by eversion of the edges.

The brain may be studied further by a number of different methods, according to the facilities for special study and the demands of the particular case. For good routine work we recommend immediate fixation in ten percent formalin solution for a period of ten to twenty days before the section of the brain. If pathologic processes requiring a variety of special fixatives are present, the operator had best section the brain immediately and select fresh tissue for fixation. The two most commonly used methods of sectioning the brain are modifications of the Edinger and of the Virchow techniques. The modifications of the Edinger technique are carried out on fixed brains. The Virchow method is designed particularly for the examination of the fresh brain.

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Fixation of the Whole Brain. The brain is placed in a large glass jar or a crock containing ten percent formalin solution. The brain should be suspended and should hang completely free on all sides. If this precaution is not observed the shape of the brain will be distorted. A piece of string is passed beneath the basilar or vertebral artery at the base of the brain. As soon as the brain has been placed in the jar of formalin, the attached string is fastened to a piece of string which is tied tightly around the jar about one centimeter from the top. On each side of the jar a small bottle cork is fastened to the string. The ends of the string which has been passed through the basilar artery are now pulled until the best position for the brain, completely submerged in the formalin solution, has been found. When the ends of string have been securely wound around the corks, the lid of the jar may be placed in position. No great strain is placed upon the string or the basilar artery by the weight of the brain because of the high specific gravity of the formalin solution.

A glass jar, measuring twenty-five centimeters in height and thirty centimeters in external diameter is recommended by L. Pick.[4] This jar is large enough to hold two brains conveniently. A glass rod is attached across the jar just beneath the top and the brains are suspended by string from the rod.

Some pathologists, desiring more thorough fixation, prefer to make an incision through the roof of each lateral ventricle before the brain is placed in the formalin solution. For the best results the formalin solution should be renewed after twenty-four hours and after forty-eight hours. This is not a necessity, however, in the usual routine autopsy.

The brain may be better handled if partial fixation is carried out before the calvarium is removed. When the organs of the thorax and the throat have been taken from the body, and the carotid arteries have been ligated, a solution of ten percent formalin is injected into the carotid arteries. The brain is removed from the skull following a delay of six to twelve hours. The partially fixed brain is then placed in ten percent formalin solution for a number of days (seven to fourteen) until fixation is complete.

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Section of the Brain after Fixation. After washing the fixed brain for thirty minutes to remove the odor of formalin the operator places the organ on a platter and examines it again externally. The fixed brain is sectioned by a long, thin, broad brain knife (Fig. 17). The macrotome of Edinger (or the

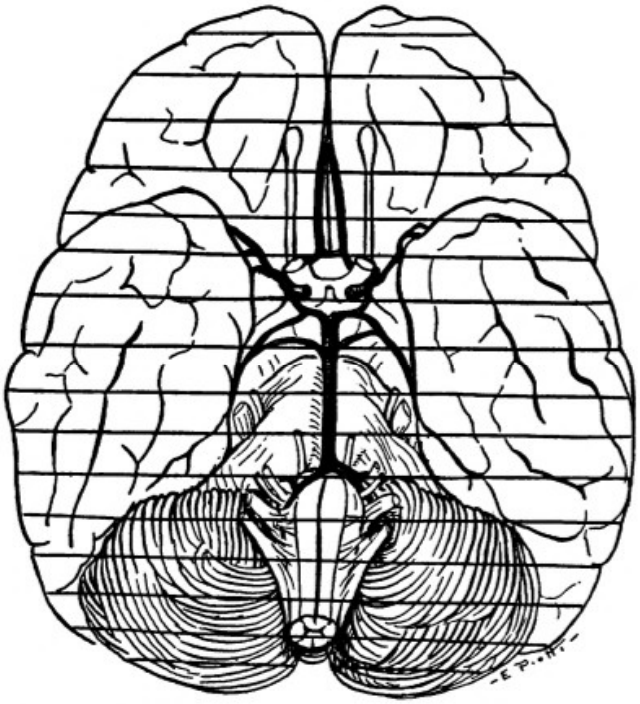

FIG. 17. Section of the brain after fixation. The brain is placed upward on the cutting board. The lines indicate a convenient method of making parallel transverse sections through the entire brain in the routine case. The thickness of the slices may vary from five millimeters to several centimeters.

Stevens brain slicer) may be used to advantage, particularly when thin slices are desired.[5] The brain is pressed against a glass plate, adjacent to which are three grooves into which the brain knife may be placed. These grooves are calibrated to permit sections at two, five or ten millimeters. With the use of the Stevens brain slicer, the brain may be cut in the horizontal, sagittal, or transverse planes in sections varying in thickness from five millimeters to several centimeters. The operator may cut transverse sections at right angles to the curve of the con-

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vexity of the brain by angulating both the guides for the brain knife and the glass plate against which the brain is placed when it is being cut. Each section through the brain whether made by free hand or with the aid of a macrotome should be made with one long sweeping incision which begins at the heel of the blade and ends at the tip. Sawing incisions should be avoided.

Now the operator must make his choice, according to the demands of the individual case, among several available methods of sectioning the fixed brain.

Method one. Fischer-Wasels recommends seven frontal sections: The first three incisions go perpendicularly through the brain; the remaining four pass obliquely backward. The seven incisions lie in the following positions:

1. The first incision is made in the middle of the frontal lobe just posterior to the olfactory bulb. In the resultant section the anterior end of the corpus callosum connects the apices of both hemispheres.
2. The second incision is made just anterior to the optic chiasm. The section includes the apices of the temporal lobes. Beneath the corpus callosum, which connects both hemispheres, are the septum pellucidum and the fornix, below which the anterior commisure is seen. The body of the caudate nucleus projects into the lateral ventricles on each side. Lateral to the caudate nucleus is the internal capsule and the lenticular nucleus.
3. The third incision passes just posterior to the optic chiasm through the mamillary bodies. Beneath the corpus callosum and usually attached to it, lie the fornix peduncles. The internal capsule, the lenticular nucleus and the claustrum, are seen as in section two. At the base of the thalamus, which is well exposed, are the mamillary bodies.
4. The fourth incision passes just in front of the most anterior border of the pons and is carried through the cerebral peduncle and posterior to the mamillary bodies. This incision is directed obliquely backward, as are the succeeding three incisions.
5. The fifth incision passes through the middle of the pons

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and meets the posterior mamillary bodies and the aqueduct of Sylvius. The pineal body which lies in front of the posterior mamillary bodies falls between two incisions and may be dissected free at this time if the pia between the hemispheres is cut away. Severing the corpus callosum, the fifth incision thus separates the hemispheres.

6. The sixth incision passes through the medulla oblongata and through the cerebellum.
7. The seventh incision is made through the middle of the olive and the posterior part of the cerebellum.

The cut surfaces are now inspected. The measurements of the ventricles are taken and the ependymal surfaces are observed. During such an inspection the young pathologist should make frequent use of an atlas of the structure of the brain, so that he may identify with certainty all anatomic structures. If tuberculous meningitis is present the brain should be sectioned for the discovery of tuberculomata, either by free hand or with the aid of a macrotome, at intervals of five millimeters.

Method two. The fixed brain may be divided in the midline by a sagittal incision which completely separates the hemispheres and divides the cerebellum, pons and medulla. The operator may then carry out a series of frontal incisions in one half, and a series of longitudinal incisions in the other half of the brain.

Method three. In certain cases, the operator may choose to make a series of horizontal incisions through the entire brain. For this procedure the brain is placed base down on a platter.

Section of the Fresh Brain (Virchow). When the brain must be sectioned immediately the method of Virchow should be used. After careful examination of all external portions of the brain with particular attention to the vessels at the base of the brain, the operator places the brain base down on a platter. The occipital lobes should be turned toward the operator. The left hand is placed over the convexity of the left hemisphere and the thumb inserted in the longitudinal fissure. The left hemisphere is then drawn to the left so that the corpus callosum is

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exposed. All incisions are made with a long, thin, narrow knife. The lateral ventricle is opened by a vertical incision which passes through the roof of the lateral ventricle just below the corpus callosum at a point approximately three millimeters external to the median raphe of the corpus callosum and directly adjacent to the fornicate gyrus. The incision is then prolonged at both ends to lay open the anterior and posterior horns of

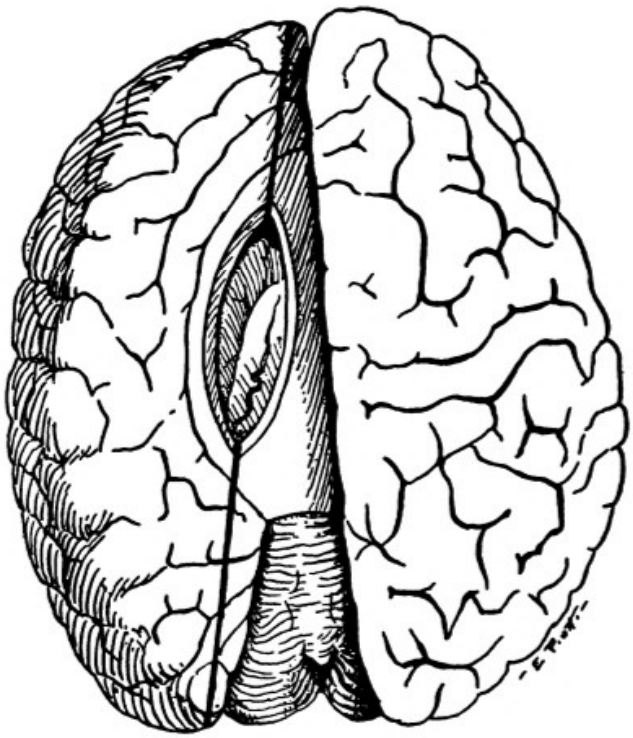

FIG. 18. First step in the Virchow method for the section of the fresh brain. Modification after Nauwerck.

the lateral ventricle (Fig. 18). The character and quantity of fluid in the ventricle and the appearance of the ependymal surfaces are now noted. The right lateral ventricle is exposed in a similar fashion. In each hemisphere two incisions are begun at both ends of the first incision. They proceed through the roof of the lateral ventricle and meet at an angle of forty-five degrees just lateral to the basal ganglia. The operator then inserts the tip of the knife through the foramen of Monro and by means of an upward stroke of the knife cuts the corpus

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callosum and fornix transversely. Reflecting the cut ends of the corpus callosum he now brings into view the velum interpositum and the choroid plexus. He may lay the third ventricle open to examination by drawing back the velum interpositum. An incision made transversely through the right posterior pillar of the fornix and adjacent brain exposes the corpora quadrigemina. The fifth ventricle is viewed by means of an incision into the septum pellucidum directly in the midline and parallel to the corpus callosum. In making this incision the operator elevates the anterior fornix and tautens it with his left hand. An incision through the middle of the pineal gland, the corpora quadrigemina and the upper vermis of the cerebellum, opens the aqueduct of Sylvius and the fourth ventricle, which are now inspected. When making this incision the operator places his left hand just beneath the pons so as to prevent injury to the floor of the fourth ventricle.

In sectioning the cerebellum the operator places his left hand beneath the left half of the cerebellum, which is then divided by a midline incision. Each part of the left half of the cerebellum is now further divided by a number of incisions which radiate like the spokes of a wheel from the peduncles. The other half of the cerebellum is sectioned in the same manner. The pons, the medulla, and the attached portion of the cervical spinal cord are sectioned by a series of transverse incisions spaced at intervals of one-half to one centimeter (Fig. 19).

The cerebral hemispheres are now sectioned further. The hemispheres are first separated from the basal ganglia by a straight, deep, antero-posterior incision which passes completely through the brain at both ends and only superficially at the middle. A further longitudinal incision incompletely dividing each hemisphere passes through the apex of the resulting wedge-shaped section of brain. A series of similar incisions, each bisecting the most recently formed wedge-shaped section, is then made. All cut parts of the hemispheres should remain connected, like pages in a book.

Next the basal ganglia are sectioned. Placing his left hand beneath the brain, the operator begins a series of frontal sec-

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tions at the anterior end of the corpus striatum and carries them through the entire basal ganglia. As each incision is made, the left hand supporting the brain is withdrawn slightly so that the cut portion falls forward and permits a good view of the cut surface.

The brain may be reconstructed so that pathologic changes

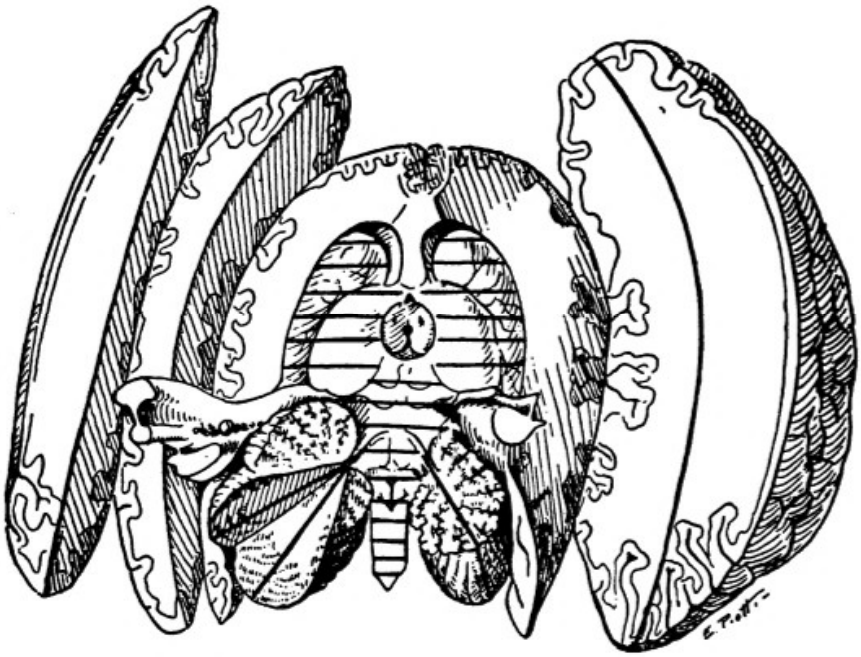

FIG. 19. Method of Virchow for the section of the fresh brain. The lines indicate the paths of successive incisions. Modification after Nauwerck.

may be reviewed in continuity. Suitable sections are removed for histologic study and placed in the proper fixatives.

REFERENCES

1. HARKE, T.: Die Sektion der oberen Athmungswege, Berl. Klin. Wchschr., **29**:744, 1892.
2. DUNN, F. L., and RHEA, D.: Core Drill (Trephine) for Postmortem Exposure of Accessory Nasal Sinuses, Nasal Passages, Mouth and Pharynx, Arch. Path., **15**:255, 1933.
3. VON HANSEMANN, D.: Die Luxation des Schaedels als Sektionsmethode, Centrabl. f. allg. Path. u. path. Anat., **20**:1, 1909.
4. PICK, L.: In Sektionstechnik by C. Nauwerck, Jena, G. Fischer (Sixth Edition) 1921.
5. STEVENS, H. C.: A New Brain Slicer, Arch. Path., **12**:90, 1931.

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CHAPTER VIII

SECTION OF THE VISCERA

ALL KNIFE CUTS through organs are made by long sweeping incisions which begin at the heel of the blade and end at the tip. The knife is washed off frequently so that tissue will not stick to the blade. Sawing incisions are avoided because they result in ragged surfaces. The cut surfaces of organs should not be washed with water. The knife edge may be drawn lightly across the surface to wipe away blood or purulent material, or the surface may be washed with normal saline solution. Each organ is weighed after all extraneous fat and connective tissue have been dissected away and before any portions are removed. The operator need not weigh organs that are retained in connection with one another as one gross specimen for museum purposes. After the indicated incisions have been made into each organ, sections, never thicker than four millimeters, are removed for histologic examination. As each organ is examined notes are made on the following points: size, color, shape, consistency and odor. Pathologic processes are described as to size, shape, position, color and relation to normal structures. The metric system is employed for all weights and measurements.

1. SECTION OF THE THORACIC ORGANS.

Thymus. The thymus is halved by a horizontal incision. The weight of the thymus varies greatly. In the normal person its weight at birth is roughly doubled by the sixth month of age and tripled by the thirteenth year.[1] It then decreases in weight slowly. The weight of the thymus is significantly decreased in most illnesses lasting more than twenty-four hours. In its rapid reaction to the effects of disease the thymus may be compared to subcutaneous fat and lymphoid tissue. Hammar has described variations in the appearance of the normal thymus. These may be given in approximate fashion as follows:[2]

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1. *Birth to ten years of age* (childhood type). Here we find sparse interstitial connective tissue and abundant parenchyma in which the cortex, consisting of closely united follicles, is predominant.
2. *Eleven to fifteen years* (the pubertal type). There are broad interlobular septa. The parenchyma is not reduced in amount.
3. *Sixteen to twenty years* (the type in youth). In the broad interlobular septa of connective tissue, the formation of adipose tissue is proceeding at a rapid rate. There is reduction of the parenchyma. The follicles in the cortex, decreased in number, are separated from each other by wide interfollicular septa.
4. *Twenty-one to forty-five years* (the type in the age of manhood). The interstitial tissue consists mainly of adipose tissue. Narrow strands of parenchyma are widely separated and cortical follicles are small and few in number.
5. *Forty-five years of age to old age.* The thymus consists of narrow strands of atrophic parenchyma. No prominent follicles are present.

Heart. The operator may choose between two methods of opening the heart.

Method one. This is the Virchow method with slight modifications. The heart is opened by means of an enterotome (or dissecting scissors in young individuals). In general, when the scissors enter a ventricle, the apex of the heart is pointed away from the operator; when the scissors leave a ventricle the apex of the heart is directed toward the operator. While the heart is being opened it may be held in the left hand, or, even better, placed on a platter and held firmly by the left hand. In entering the *right auricle,* which is the first chamber to be opened, the operator places the lower blade of the enterotome into the stump of the inferior vena cava (Fig. 20). The blade, now inserted into the right auricle, appears at the stump of the superior vena cava. After opening the auricle

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along the course of the incision thus marked out, the operator makes a second and smaller incision from the line of the first, in order to open the right auricular appendage. The right auricle and the auricular appendage are now examined and the tricuspid valve is viewed and palpated from above.

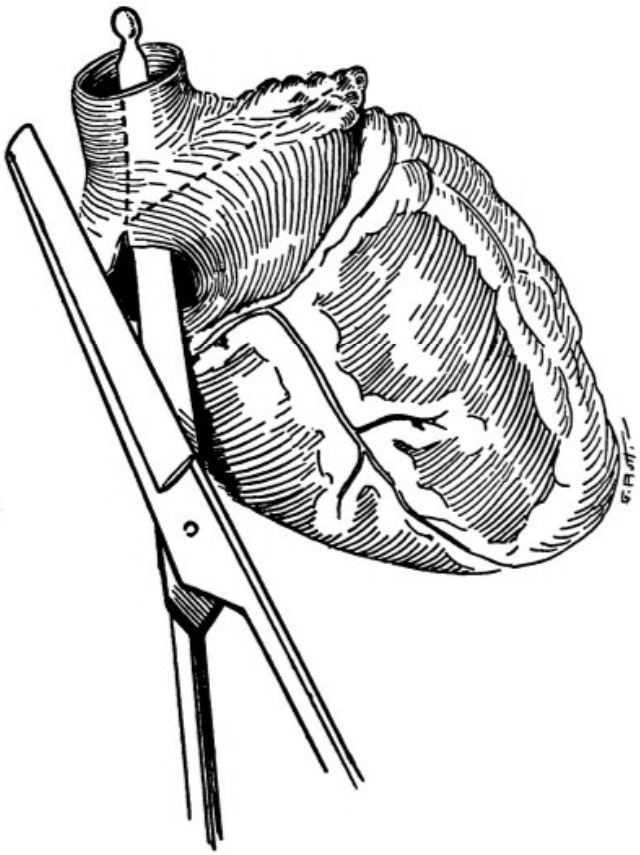

FIG. 20. Opening of the heart. Right auricle. The lower blade of the enterotome has been inserted into the stump of the inferior vena cava and emerges through the stump of the superior vena cava. The right auricle is opened by an incision which connects the two large veins. A second incision along the path indicated by the broken line exposes the right auricular appendage.

Holding the heart in such a position that the apex is turned away from him and the right border presents, the operator inserts the lower blade of the enterotome through the tricuspid valve, and cuts through the wall of the *right ventricle*

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along the extreme right border down to the end of the ventricle, which terminates a short distance above the apex of the heart. The next incision, for the execution of which the lower blade of the scissors is placed between the anterior papillary muscle and the anterior wall of the ventricle above it, begins at a point about the middle of the first incision just above the insertion of the anterior papillary muscle. Directed along the extreme left border of the pulmonary artery, it joins the previous incision which was made in the pulmonary artery *in situ* (Fig. 21). In making this incision the operator should direct the upper blade of the scissors just to the left of a narrow ridge of fat, usually present at the base of the adult heart. If properly carried, this incision will pass between the left anterior and the posterior segment of the pulmonary valve. The pulmonary valve may now be examined and the interventricular septum viewed.

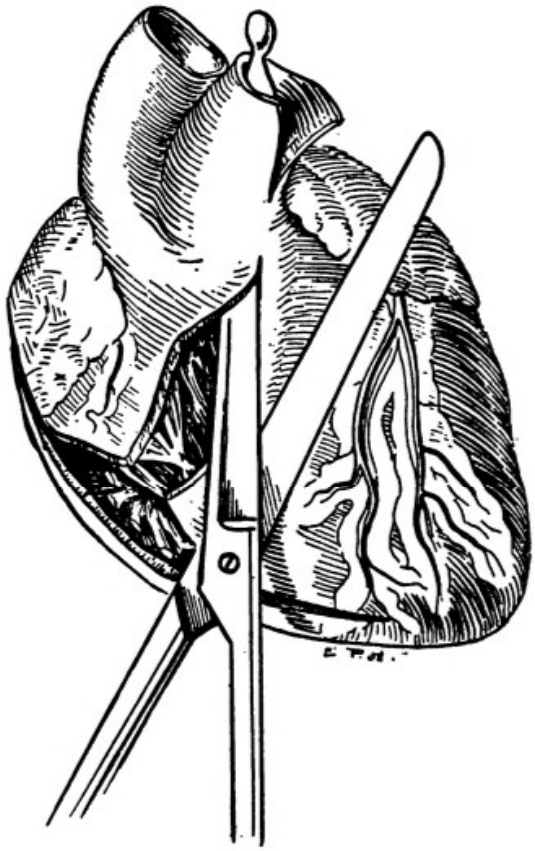

FIG. 21. Opening of the heart. Right ventricle. The right ventricle has been opened by a scissors cut which has passed through the tricuspid valve, along the right border of the right ventricle, and which has terminated a short distance above the apex. The position of the enterotome indicates the path of the third cut made to expose the pulmonary valve. The lower blade rests upon the papillary muscle; the beaded tip, which has been inserted through the pulmonary valve, emerges beyond the cut end of the pulmonary artery. This incision is continuous with a previous one which was made in the pulmonary artery *in situ*.

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The *left auricle* is opened by scissor cuts which connect the stumps of the pulmonary veins. An added incision exposes the left auricular appendage. The mitral valve may be viewed and palpated from above. The *left ventricle* is next opened. Holding the heart so that the apex is directed away from him and the left border presents, the operator inserts the upper blade of the enterotome through the mitral valve and opens the wall of the ventricle along the extreme left border down to the apex (Fig. 22). The heart is now set in position, apex toward the operator, for the final incision, which begins at the apex and continues along the right border of the left ventricle close to the interventricular septum (Fig. 23). It passes parallel to and about one centimeter from the descending branch of the anterior coronary artery. The lower blade of the scissors is then cautiously passed through the aortic valve until the beaded end appears in the stump of the aorta. Holding the enterotome is this position, the operator draws the pulmonary artery to the left by means of forceps, and then carries out an incision along the left border

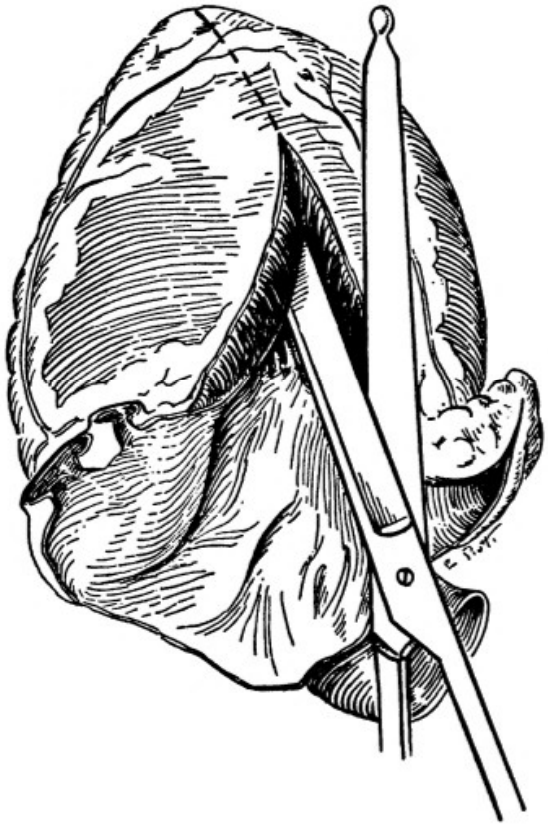

FIG. 22. Opening of the heart. Left auricle. The left auricle has been opened. After the upper blade of the enterotome has been inserted through the mitral valve, the scissors cut has been continued along the left border of the heart. The dotted line which is carried to the apex of the heart indicates the path of the remainder of the incision.

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of the aorta where it leaves the heart between the left auricular appendage and the pulmonary artery. The aortic valve may now be examined.

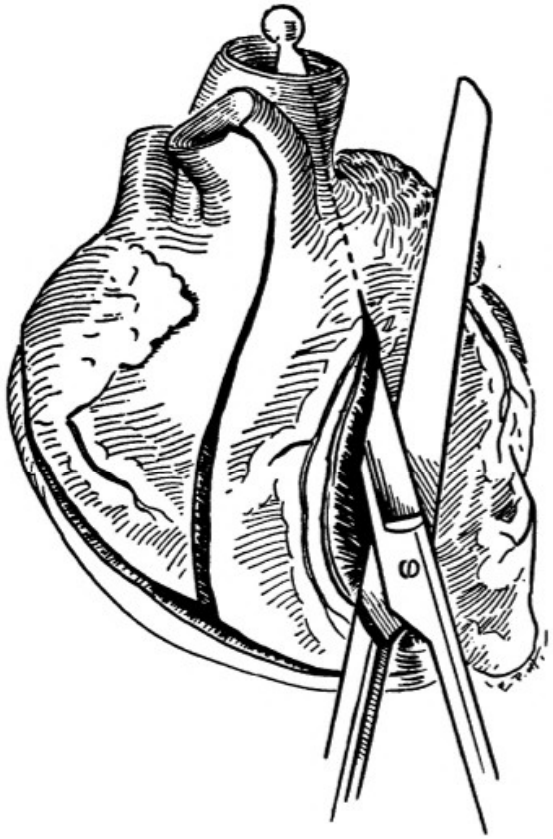

FIG. 23. Opening of the heart. Left ventricle. The two incisions in the right ventricle are shown. The left ventricle has been opened along the left border down to the apex. The illustration shows the path of the final incision designed to expose the aortic valve. An incision has been made through the wall of the left ventricle close to the interventricular septum. The lower blade of the enterotome, inserted through the aortic valve, emerges above the cut end of the aorta. The pulmonary artery is drawn to the right so that it will not be cut when the remainder of the incision through the aortic valve is completed.

There are then four incisions required in order to open the heart and expose the valves after the opening of the auricles. They may be listed as follows:

1. Incision along the right border of the right ventricle down to the termination of the ventricle above the apex.
2. Incision beginning at the middle of the first cut and passing through the anterior wall of the right ventricle above the papillary muscle into the pulmonary artery.
3. Incision along the left border of the left ventricle down to the apex.
4. Incision from the apex of the heart along the interventricular septum,

then between the pulmonary artery and the left auricular appendage and finally into the aorta.

The operator should not insert a probe into the coronary

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arteries to determine their patency, lest he dislodge thrombi. The coronary arteries are best opened by a small scalpel. Small wedge-shaped segments of the roof of the ventricle may be lifted off for as great a distance along the course of the coronary vessels as is necessary. If these cuts are made carefully with an upturned blade, thrombi, when present, will be left undisturbed in their original positions.

When an infarct of the heart is suspected from external examination, a single long knife incision is made. This begins in the midline at the apex, passes to the left of the interventricular septum through both the anterior and the posterior wall of the heart, and finishes just to the left of the base of the aorta.[3] The coronary arteries may now be exposed in the manner described above. Special attention is usually paid to the descending branch of the anterior coronary artery. The coronary vessels may also be examined by a series of small transverse incisions through the artery a short distance into the myocardium. A single oblique incision through the myocardium of the left ventricle reveals scars in the myocardium.

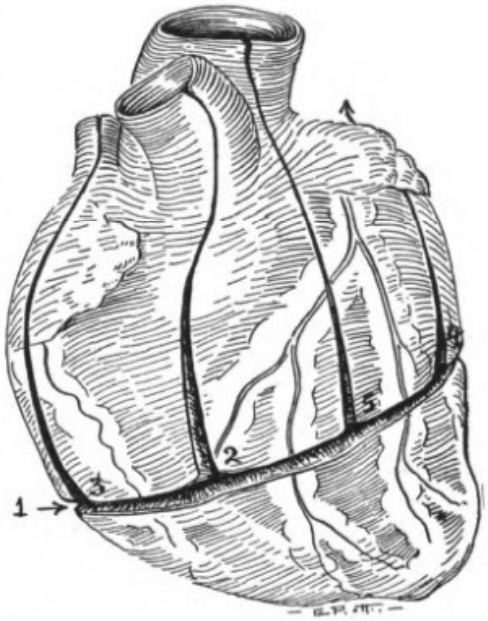

FIG. 24. Opening of the heart by a modification of the Zenker technique. The illustration shows the order and direction of the five incisions.

Method two. A second method used in opening the heart is a modification of Zenker's technique recently described by Roessle.[4] It comprises five main incisions (Fig. 24). Holding the heart firmly in the left hand, the operator makes a long incision from the left border of the heart to the right in a line perpendicular to the long axis of the heart. The incision, dividing both ventricles through the midline, is carried down

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through the anterior wall of the ventricles but not through the posterior wall. Four enterotome cuts beginning in the line made by this incision lay open the vales. The first cut, passing along the left border of the interventricular septum into the pulmonary artery, may be carried, if the lungs are still attached, as far as the root of the left lung, in order to open the left main branch of the pulmonary artery. The second scissors cut proceeds along the right border of the right ventricle and through the tricuspid valve. along the lateral border of the right auricle. Having followed along the extreme left border of the heart, the third incision continues through the mitral valve and along the lateral border of the left auricle. Finally, exercising particular care that the pulmonary artery is not damaged, the operator carries the last scissors cut along the right side of the interventricular septum and out through the aorta.

Now that all parts of the heart are fully exposed, more detailed examination may be carried out. Notes are made on the appearance, color and consistency of the epicardium, pericardium, myocardium and endocardium. The color and character of the blood in the four heart chambers is noted as the heart is opened. Particular care must be used in the removal of clotted blood which may be attached to the valves or to the chordae tendineae in order to prevent the destruction of vegetations or thrombi. Congenital defects are sought for and examined. The thickness of the wall of the left ventricle and of the right ventricle is measured. Measurements of the thickness of the myocardium have no value unless they are taken always at the same levels and unless the heart is opened by the same technique in every case. Next is taken the circumference of the valves, of the pulmonary artery and of the ascending portion of the aorta. The height of the heart may be measured from the base of the aortic valve to the apex. Finally, the heart is weighed after all blood clots have been removed. Sections are now selected for histologic examination.

The size of the circumference of the heart valves depends in part upon the degree of contraction of the heart. The pa-

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thologist may be aided by comparison with the following average measurements of parts of the adult heart (Roessle):

1. Thickness of left myocardium . . . 1.0-1.2 cm.
2. Thickness of right myocardium . . . 0.3-0.5 cm.
3. Circumference of the opened:
   a. Mitral valve . . . 9-10 cm.
   b. Tricuspid valve . . . 10-12 cm.
   c. Pulmonary artery above the pulmonary valve . . . 6.3-7.2 cm.
   d. Aorta above the aortic valve . . . 5.5-7.7 cm.
4. Circumference of the aorta averages:
   a. At the level of the diaphragm . . . 3.7-5.5 cm.
   b. At the bifurcation of the aorta . . . 2.8-4.7 cm.

When detailed microscopic studies of the heart are to be made the following standardized procedure of Gross, Antopol and Sacks may be used to advantage.[5] The heart, opened in the customary manner, is fixed in a neutral formaldehyde, sodium chloride solution (solution of formaldehyde, U.S.P., ten parts; one percent sodium chloride solution, ninety parts; the whole solution rendered neutral by a weak alkali). Small blocks may be fixed in alcohol or in other solutions when indicated. After fixation of the whole heart six blocks are selected for microscopic study. These are obtained in the following manner (the terminology of Gross is retained):

1. *Left auricle.* A transverse cut approximately three centimeters in length is made with a pair of scissors from the posterior cut border of the left auricle toward the interauricular septum, approximately one centimeter above the insertion of the posterior flap of the mitral valve. A cut is made parallel to, and approximately three millimeters above, the first cut. The right border of the narrow slab is severed with a knife.
2. *Mitral posterior.* From the defect made by the removal of the first section a vertical cut is made with a scalpel down toward the apex of the heart, in such a way that the blade passes through the posterior leaflet of the mitral

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valve and the subjacent myocardium. The incision is carried through the myocardium to a point about three millimeters below the free edge of the valve. After a parallel cut has been made, the block is removed.

3. *Posterior papillary muscle, left.* A longitudinal scalpel incision starts at the apex of the posterior papillary muscle and continues down into the base. Parallel to this cut, another is made. The block is then removed.
4. *Aorta, aortic valve and mitral valve.* Grasping the anterior segment of the left ventricle in the left hand, the operator inserts a pair of scissors beneath the anterior (aortic) flap of the mitral valve in such a way that one blade lies against the auricular surface of the aortic flap of the mitral valve and the other blade lies against the posterior (non-coronary) cusp of the aortic valve. The incision is carried upward through the middle of the posterior cusp of the aortic valve and through the lower portion of the aorta. After a second incision has been carried out parallel to the first, the block is removed.
5. *Pulmonary artery and valve.* A transverse incision beginning at the right cut border of the pulmonary artery several millimeters above the free edge of the anterior cusp of the pulmonary valve, is carried to a point approximately opposite the middle of the anterior cusp. Turning the scissors toward the apex of the heart, the operator now cuts through the base of the pulmonary artery, the anterior pulmonary cusp and the right ventricular myocardium as far as a point about one centimeter below the base of the anterior pulmonary cusp. After a vertical incision has been completed parallel to the first the block is removed.
6. *Tricuspid valve and septum.* The point of the scalpel, inserted through the right auricle at a point about one centimeter above the insertion of the septal flap and five millimeters to the right of the septal-anterior commissure, emerges below the posterior cusp of the aortic valve. The blade is carried toward the apex through the right auricle, the septal cusp of the tricuspid valve and the subjacent

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interventricular septum to a point about one centimeter below the free edge of the septal cusp. An incision is made approximately three millimeters to the left of the first cut and the block is removed.

The six blocks thus removed include sections of all four heart valves; the pericardium of the left and right sides of the heart; the left and right auricles; the myocardium of the left ventricle, right ventricle, interventricular septum and left posterior papillary muscle; the bases of the aorta and the pulmonary artery; the pericardial wedges abutting against the valve rings; the neuromuscular bundle and the coronary tissues. The removal of the sixth block, which includes the neuromuscular bundle, does not interfere with complete serial sectioning of the conduction system when such study is to be carried out.

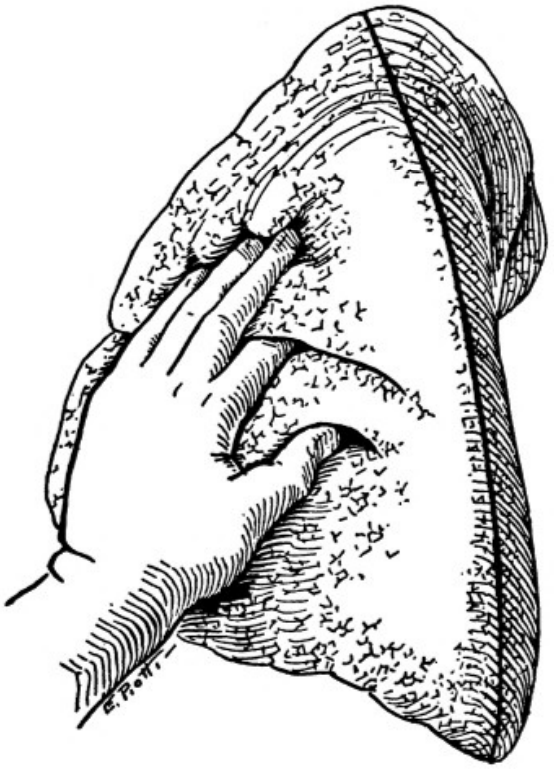

FIG. 25. Section of the lungs by the method of Nauwerck. A long sweeping incision is carried from the base to the apex of the right lung and from the apex to the base of the left lung.

Lungs. The left lung, placed on a platter and held firmly by the hand, is opened in book fashion by a long incision running from the apex to the base and extending to the hilus where it meets the artery and the bronchus. The right lung is sectioned in a similar manner except that the incision is carried more conveniently from the base to the apex (Fig. 25). When indicated by palpation of the lung, a number of parallel incisions may be made into the various lobes to reveal pathologic processes more clearly. After the cut surfaces of the lungs have been examined, the branches of the pul-

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monary vessels and of the bronchi are opened as far as possible by means of a small scissors. Since it is not possible to open both arteries and veins in continuity in the same lung, the operator had best open carefully the arteries in one lung and the veins in the other. The cut ends of the vessel not opened may then be examined on the cut surfaces of the lungs.

According to another method, the lungs may be opened by means of four incisions in the right lung and three in the left. Each lobe is opened by a long sweeping incision. An additional incision is made through each lung on its posterior surface along the vertebral border from apex to base. The vessels and bronchi are opened in the usual manner. An incision in the peribronchial lymph nodes separates the glands into two parts. After the lungs have been weighed and indicated measurements of pathologic lesions taken, sections are removed for histologic examination.

2. SECTION OF THE THROAT AND POSTERIOR THORACIC ORGANS. The specimen consisting of the throat organs and the attached esophagus and thoracic portion of the aorta, is placed on a platter in such a way that the tongue is directed away from the operator and the esophagus presents anteriorly. The enterotome, inserted into the cardiac end of the *esophagus,* makes a midline cut along the entire length. The mucosal surface and wall of the esophagus are now examined. The thoracic portion of the *aorta* including the arch and its branches is next opened by means of scissors. The thickness of the wall and the color and appearance of the intimal surface are noted. Single midline longitudinal incisions open the *tonsils*. After the *tongue* and the attached portion of the pharyngeal wall have been examined, a series of parallel transverse sections are made through the tongue.

Attention is now paid to the *epiglottis* and to the *larynx*. The position of the specimen is changed so that the tongue is directed toward the operator. A scissors cut, opening the larynx in the midline and proceeding downward through the trachea into both main bronchi, exposes for examination the inner surface of the larynx, the vocal chords and the aryepiglottic folds. Foreign bodies, diphtheritic membranes, edema of the glottis,

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or retropharyngeal abscess, are some of the important pathologic findings in this region. The color and appearance of the mucosal surfaces of the trachea and attached portions of the primary bronchi are noted and a description of the contents of the trachea is made.

After the adherent muscle overlying the *thyroid* has been dissected away, longitudinal incisions are made in both lateral lobes. A single transverse incision may be extended through the middle lobe of the thyroid and continued through the trachea. The thyroid is best dissected free and then weighed and sectioned.

The *parathyroid* glands, usually four in number, but occasionally six, are recognized as small yellow-brown encapsulated masses situated most often in the loose connective tissue which forms the external covering of the thyroid gland. The superior parathyroid gland is commonly found on the posterior border of the thyroid at the middle or at the junction of the upper and middle third of the thyroid gland opposite the cricoid cartilage. The inferior parathyroid is situated near the lower pole of the thyroid. The parathyroid glands may be found high in the neck, in the mediastinum or even completely embedded in the thymus or thyroid.

3. SECTION OF THE ORGANS OF THE ABDOMINAL CAVITY.

Spleen. The spleen is sectioned by one long incision which passes from the convexity to the hilus. Now the thickness of the capsule is measured. The cut surface is viewed after it has been gently stroked by the edge of the knife. The operator notes the prominence of the Malpighian corpuscles and the amount of pulp that can be scraped away by the knife edge. The location and number of notches along the edge of the spleen are recorded. As many incisions as are needed may be made parallel to the first one. The spleen of the adult measures in length twelve to fourteen centimeters, in width eight to nine centimeters, in thickness three to four centimeters.

Pancreas. The pancreas is dissected free from its connections with the duodenum and the adjacent organs with which it was removed. A transverse cut which passes completely through the head of the pancreas, now discloses the pancreatic duct in

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cross section. If abnormalities are present the duct may be dissected by fine scissors. In the usual case a longitudinal incision is carried through the midline of the pancreas. The operator may now view the cut surface and note the size and symmetry of the lobules. The pancreas of the adult varies from nineteen to twenty-two centimeters in length. The weight of the pancreas of the adult in whom no evidence of pancreatic disorder is demonstrable, ranges from sixty to one hundred and sixty grams, with an average of ninety-five grams.

In autopsies on diabetic patients, Warren recommends the removal of the pancreas as soon as the body is opened.[6] The pancreas is freed at the tail, after the gastrocolic omentum has been cut and stripped upward and to the right. After possible abnormalities in the pancreas have been noted, the portion of the head most closely adherent to the duodenum is severed from the body of the pancreas, which is then removed. The portion of the head of the pancreas is dissected free at the time of the subsequent section of the organs. Transverse sections, one to two millimeters in thickness, are cut and placed in various fixatives.

Liver. If the liver has been removed with the stomach, duodenum and pancreas, it is now freed by the severing of the hepatoduodenal ligament. The surface of the liver, usually brown or brownish-red in color, is first viewed through the capsule of Glisson. If a horizontal incision has been made through the liver *in situ,* the cut surface may now be inspected. If such a cut has not been made, a long horizontal incision which completely halves the liver is now carried out. Lobular markings are seen only when the color at the center differs from that at the periphery of the lobule. Such a condition can be caused by a large amount of blood at the center of the lobule or fat at the periphery. The small dark spots interspersed over the cut surface usually indicate the centers of the lobules. Now a section is made parallel to, and one centimeter from, the first horizontal incision. The operator may test the consistency of the liver by palpation and by observation of the amount of resistance encountered when he breaks through the thin section of liver with his fingers. As many incisions as are desired may

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be made parallel or perpendicular to the horizontal incisions. The branches of the portal vein and hepatic artery are dissected and followed within the liver substance. The average measurements of the liver of the adult are twenty-eight by twenty by nine centimeters. It has been estimated that the loss of blood on removal of the liver from the body causes a reduction of fifty grams in the weight of the liver.[7]

Gall Bladder. After the gall bladder has been opened by a longitudinal scissors cut, the contents are measured and examined. The mucosal surface is more closely inspected when the bile has been removed. Special attention is paid to the presence of stones or golden yellow deposits of cholesterin on the mucosal surface. The thickness of the wall is measured. The gall bladder of the adult varies from eight to seventeen centimeters in length and averages three and one-half centimeters in width at the fundus. It contains usually about fifteen cubic centimeters of bile. The common, cystic and hepatic ducts are now opened by fine dissecting scissors.

Adrenal Glands. The adrenals are stripped of surrounding fat or fibrous tissue and the external surfaces are examined. A series of transverse incisions pass almost completely through each organ. On the cut surface the cortex and the medulla are usually well differentiated: the cortex is yellow and opaque; the medulla is usually gray in color. The adrenals of infants and children are described in Chapter X.

Kidneys. The kidneys may be sectioned in one of four ways:

Method one. While still in the body each kidney is freed from all connections except that with the ureter. The kidney is then drawn vertically upward and placed in the palm of the left hand. Holding the ureter between the third and fourth fingers, the operator draws his left hand upward as far as possible, so that he tautens the ureter. He then makes a long incision from the convexity of the kidney through to the hilus, but does not separate the halves of the kidney. The beginner is advised to place a piece of gauze or cloth between the palm of his hand and the kidney for added protection against accidental cuts.

Method two. Having placed the removed kidney, present-

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ing the pelvis toward the left and the convexity toward the right, on the platter, the operator rests the fingers of his left hand on the upper surface of the kidney to keep the organ steady, and makes a long horizontal incision from the convexity to the kidney hilus. An additional preventive against slipping is a piece of gauze or cloth placed between the operator's fingers and the kidney.

Method three. Through the kidney, which is held, convex surface upward, in the left hand, a long incision is made from the convexity to a point about half-way through the kidney substance. The organ is then reversed and the pelvis presented upward. A second incision is begun at the hilus to meet the first incision.

Method four. The operator holds the kidney between the thumb and forefinger of his left hand in such a way that his thumb is on the left side and the convexity presents anteriorly. Then the knife, placed on the convexity of the kidney beneath the palm of the left hand, is drawn through the kidney to the hilus.

Beginning at the convexity, the operator now strips the capsule from the opened kidney by means of mouse-toothed forceps and observes the color and appearance of the external surface. Small surface furrows which are sometimes found in the adult represent remnants of fetal lobulations. The edges of the cut surfaces are now examined for evidence of eversion. The thickness of the cortex is measured and the appearance of the cortical striations examined. When the glomeruli are filled with blood they appear as tiny red points on the cut surface of the body. The cortex is usually gray in color. The color and appearance of the pyramids and of the medulla of the kidney are then described. The parenchyma is usually transparent; not opaque or cloudy. After the calyces have been opened wide by scissors cuts, the color and the appearance of the pelvic mucosa may be inspected. The kidney of the adult measures eleven by six by three centimeters; the cortex averages five to six millimeters in thickness. The left kidney usually weighs five to seven grams more than the right.

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Pelvic Organs. The pelvic organs, bladder presenting anteriorly, are placed on a platter.

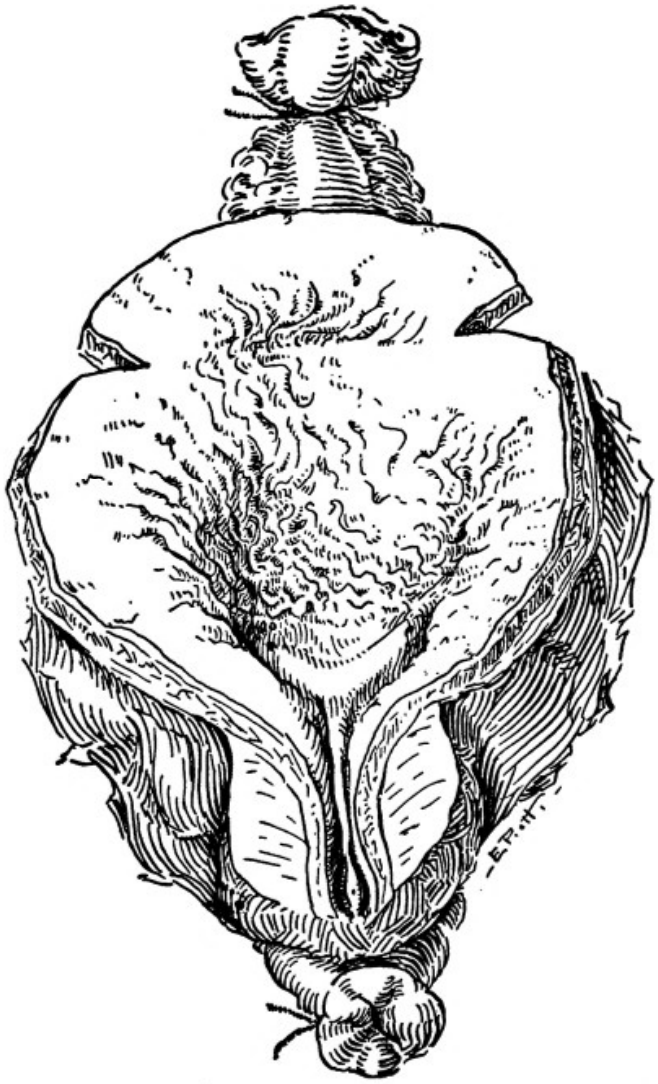

FIG. 26. Pelvic organs of the male. The anterior wall of the bladder has been opened in the midline by an incision which was begun in the posterior urethra. A transverse incision perpendicular to the first has been carried to both lateral borders of the bladder. The posterior urethra and the opened prostate are shown. The tied ends of the rectum are seen above and below.

Male. The lower blade of the scissors is introduced through the cut end of the urethra and passed into the *urinary bladder.* The anterior wall of the bladder is then incised in the midline as

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far as the dome. A transverse incision perpendicular to the first cut is carried to both lateral borders of the bladder (Fig. 26). The contents of the bladder are collected and measured and the mucosal surface is viewed. The ureteral orifices are probed and the appearance of the trigone inspected. Now a transverse incision is made through the pars membranacea and the *prostate* down to the posterior bladder wall.

The *seminal vesicles* lie as long flattened structures lateral to the spermatic ducts, immediately above the prostate and attached to the posterior wall of the bladder. Fastened to the bladder by the rectovesical fascia, they diverge on either side toward the ureters, which they overlap and which intervene between the vesicles and the bladder wall. The vasa deferentia run along the inner border of the vesicles and join the ducts from the vesicles to form the common ejaculatory ducts just before entering the posterior portion of the prostate. The seminal vesicles and the ductus deferens may be exposed either by the method of Nauwerck or by means of blunt dissection in the peritoneum in the depth of the rectovesical excavation. By the method of Nauwerck, the pelvic organs are lifted in such a position that the rectum is placed toward the operator and the neck of the bladder is situated at the top of the specimen.[8] The operator holds up the fundus of the rectovesical excavation and places his index finger into the incision which has been made in the prostate, his middle finger on the posterior wall of the bladder and his thumb on the anterior surface of the rectum. Having pulled the rectum forcefully downward with his thumb, the operator exposes the posterior portion of the neck of the bladder upon which rest the seminal vesicles. A transverse incision is made through the peritoneum in the depth of the rectovesical excavation so that the peritoneum may be pulled away both superiorly and inferiorly. A longitudinal incision is then made through each seminal vesicle. If the seminal vesicles are not found with ease, the operator should identify the ductus deferens, which is then opened by fine dissecting scissors as far as the seminal vesicles.

The *testes*, held between the thumb and forefinger of the

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left hand, are halved by a long incision down to the epididymis.

After the *rectum* has been opened by a midline enterotome incision, the feces are examined and removed, and the mucosal surfaces inspected.

The calibre of the *posterior urethra* is measured. Finally the *verumontanum* is inspected.

Female. The pelvic organs are placed on the platter in such a position that the bladder presents anteriorly. After being opened as in the procedure for the male, the *bladder* is dissected free from its attachments below, or divided in two by the scissors cut which passes through the vagina. Cutting through the bladder, the operator opens the attached portion of the *vagina* and the anterior vaginal vault to the cervix of the uterus in the midline. After the lower blade of the scissors has been inserted into the external orifice of the uterus, scissors cuts open the *uterus* to the fundus in the midline. Two lateral cuts at the upper end of this incision open the horns of the uterus to the tubes. The mucosal surface may now be viewed. The perimetrium is examined and the wall is palpated for evidence of new growth. If desired, a series of long parallel incisions may be made in the posterior and lateral walls of the uterus for a closer examination of the blood and lymph vessels.

After a longitudinal incision has been made through each ovary, the tubes may be opened by dissecting scissors or by a series of transverse knife incisions. The pouch of Douglas is next examined for evidence of tuberculosis or tumor metastases. The rectum is opened as in the male.

Gastro-intestinal Tract. The pharynx and esophagus are usually opened and examined when the tongue and the throat organs are sectioned. The duodenum is always opened *in situ* if the liver is removed separately. When the liver, duodenum, pancreas, and stomach are removed in one piece, the duodenum may be opened on the platter for the examination of the papilla of Vater and for the test of bile duct patency.

The *duodenum* is opened in the midline if it has not been opened before. The color and consistency of its contents are noted. The enterotome incision is then carried through the

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pyloric ring along the greater curvature of the *stomach* up to a point about one-half the distance to the cardiac end. The incision stops here so that the gastric contents may be scooped out or poured into a suitable receptacle. The gastric contents are examined for color, odor and composition. The enterotome incision is then continued along the greater curvature of the stomach to the cardiac end. Now the mucosal surface is inspected and the thickness of the wall measured at several different levels including the pyloric and cardiac ends. Portions of stomach to be taken for histologic purposes should be chosen from areas which have not been touched by the examiner's fingers.

The *small* and the *large intestines* are now opened. No autopsy may be considered complete until the intestines have been examined as carefully as all other structures and organs in the body. The occasional practice of washing the unopened intestines by means of a hose is to be condemned. On the contrary, the intestines should be disturbed as little as possible. After the beaded lower blade of the enterotome has been inserted into the upper end of the jejunum, the bowel is opened along the mesenteric border so that the lymphoid follicles which lie in the midline will not be disturbed. After the jejunum has been opened by scissors cuts for a distance of five centimeters, the end of the bowel is grasped by the left hand and pulled toward the operator while the right hand holds the blades of the scissors wide open in a fixed position. The cutting edge should be sharp enough to open the bowel simply in moving along the mesenteric surface. This procedure is carried out over a pan into which fecal material may drop. The operator should hold his arms in a position of half extension, and take especial care to prevent his left hand from drawing the bowel too near his apron. By this technique the entire jejunum and ileum may be opened without disturbance of the mucosal surface. As the bowel is opened the contents are noted. In cases where it is important to examine the contents of different portions of the bowel, the operator had best shift the position of the pan at

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definite intervals so that the fecal contents which drop from one portion of the bowel may be kept separate from those of another. Scissors cuts now open the *cecum*. The ileo-cecal valve is examined carefully. By means of small dissecting scissors the *appendix* is opened along its entire length. The large intestines are then opened in the midline by actual cuts of the enterotome.

Before any further procedures, portions of the bowel selected for histologic examination are cut out. The mucosal surfaces should not be touched by the fingers or washed with water. If the surface is to be cleansed, normal saline solution may be poured upon it.

A more careful inspection of the intestinal tract is now performed. The operator places the jejunal end of the bowel, mucosal surface upward, on the middle finger of his left hand. He closes his first finger lightly without pressing down on the surface. The left hand, meanwhile, is held out in semi-extension. The upper end of the jejunum is now grasped by the right hand and drawn over the middle finger of the left hand downward to the pan below. The fecal material remaining on the surface of the bowel is brushed off lightly by the first finger of the left hand and falls distal to the left hand. The relatively clean mucosal surface pulled by the right hand appears in full view before the operator, who carries out this procedure slowly until the entire bowel has passed between his fingers.

When indicated, bacteriologic examination of the contents of the bowel is carried out before the bowel is opened. The operator first sears the serosal surface of the bowel and then plunges a sterile scalpel through the wall in the seared area. By means of a loop introduced through this opening, material for cultures is taken.

The intestinal contents are examined for color, consistency, odor and parasites. Microscopic examination of the intestinal contents for parasitic ova or for protozoan parasites is carried out when indicated. The mucosal surface of the bowel is examined for evidence of ulceration, new growth, inflammatory

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lesions and vascular changes. The amount, the size and the appearance of the lymphoid tissue in the intestinal tract is noted.

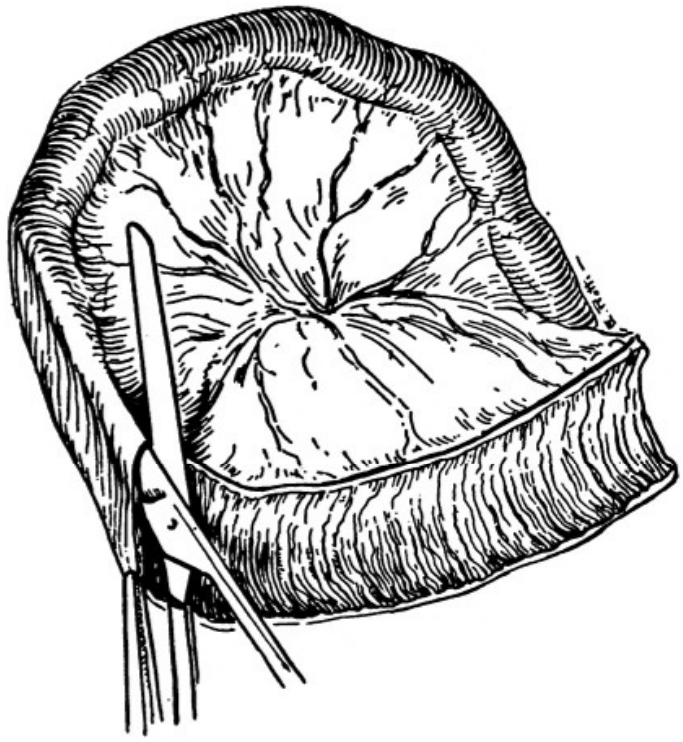

FIG. 27. Opening of the intestines by a modification of the Zenker technique. The intestines have been removed with the mesentery still attached. The intestines are opened by an enterotome incision along the mesenteric border.

If the intestines and the mesentery have been removed together, the method of Nauwerck is used in the opening of the bowel (Fig. 27). The intestines are opened along the mesenteric border with the aid of an enterotome. When lesions of the intestinal tract are found during the procedure of opening the bowel, the adjacent mesenteric lymph nodes are more carefully inspected. The retention of the attachments of the mesentery, moreover, permits careful study of the mesenteric blood vessels at this time.

REFERENCES

1. BOYD, E.: The Weight of the Thymus Gland in Health and Disease, Am. J. Dis. Child., 43:1162, 1932.

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Original from UNIVERSITY OF MINNESOTA

2. BLACKFAN, KENNETH D.: Growth and Development of the Child. Part II: Anatomy and Physiology, page 348, New York, The Century Company, 1933.
3. GORHAM, L. W., ORDWAY, T., JACOBSEN, V. C., and HISOI, K.: The Pathology of Cardiac Infection, Trans. Am. Clim. & Clin. Ass. 1932.
4. ROESSLE, ROBERT: Sektionstechnik, Berlin, Julius Springer, 1932.
5. GROSS, L., ANTOPOL, W., and SACKS, B.: A Standardized Procedure Suggested for Microscopic Studies on the Heart, Arch. Path., 10:840, 1930.
6. WARREN, SHIELDS: The Pathology of Diabetes Mellitus, Philadelphia, Lea and Febiger, 1930.
7. ROESSLE, R. and ROULET, F.: Mass und Zahl in der Pathologie, Berlin, Julius Springer, 1932.
8. NAUWERCK, C.: Sektionstechnik, Jena, G. Fischer, (Sixth Edition), 1921.

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CHAPTER IX

EXAMINATION OF THE SKELETON

1. Bone marrow. Without making additional skin incisions the operator may obtain bone marrow from the ribs and from the sternum. By means of the costotome he may remove portions of ribs which include the costochondral junction. The removed pieces of rib are split longitudinally and placed in suitable fixatives. As soon as a midline incision has been made through the removed sternum, a portion of the manubrium containing marrow may be selected for fixation. After the organs have been taken from the body, pieces of bone and bone marrow may be freed anteriorly by horizontal chisel strokes into the bodies of the vertebrae.

If bone marrow is to be removed from the femur without the removal of that bone, an incision from five to ten centimeters in length is made on the posterior surface of the thigh at a point about midway between the hip and the knee. The muscles and subcutaneous tissues are dissected bluntly from the femur until the periosteal surface is exposed. Then by means of chisel and mallet a rectangular portion of bone, including one wall of the femur and the attached marrow, is removed.

2. Removal of the bones of the lower extremities. The method given here was recently developed for use in our laboratory with the aid of L. J. McDermott. The Y-shaped incision is extended from the symphysis pubis laterally to a point midway between the anterior superior spine and the symphysis pubis. Carried from here through the skin fold of the groin along its medial aspect, the incision now curves posteriorly to a point about midway between the tuberosity of the ischium and the greater trochanter. Then it continues downward along the posterior aspect of the thigh, one-third to one-half the distance to the knee. By means of blunt dissection the skin, superficial

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fascia and areolar tissue are freed along the entire length of the incision. An incision into the muscles over the anterior aspect of the hip joint lays the hip joint open. Holding the knife vertically, the operator makes an incision in the capsule and continues it around the entire margin of the acetabular ring. The leg is then rotated externally. By means of downward traction the ligamentum teres is brought into view. After the ligament has been cut, the femoral head may be dislocated. The connections over all surfaces of the joint are now freed to permit complete disarticulation of the femur. Everting the skin, the operator dissects the skin flaps bluntly from the musculature overlying the femur with the aid of traction on the head and neck of the femur. He may continue this procedure distally as far as necessary to obtain a specimen comprising all the structures of the leg except the skin and the superficial fascia.

The femur, knee joint, ankle joint and foot as far as the proximal phalanges may be removed by the same technique. The skin incision need not be carried any further than the popliteal space for the removal of the entire leg as far as the proximal phalanges. The operator should retain the musculature with the bones and leave behind only skin and superficial fascia. If he has followed this method, he will encounter less difficulty in reconstruction than if he removed the femur or the lower bones without musculature.

Reconstruction is accomplished as follows after the removal of the femur. A piece of dowel of approximately the diameter of the femur and about two centimeters shorter than the distance from the acetabulum to the joint surface of the medial condyle of the femur, is wrapped in absorbent cotton, the proper amount of which is determined by the size of the thigh on the opposite side. The outer layers of the cotton are moistened to facilitate insertion beneath the skin. The defect made by the removal of the musculature of the gluteal regions and the greater trochanter is remedied by careful insertion and tight packing of absorbent cotton. If the ends of the dowel are covered by thin sheets of absorbent cotton so that rounded ends are formed, articulation with the acetabulum above and

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the tibia below will permit wide movement comparable to that in the joint on the intact side. When the sutures are being placed to repair the skin incision, the cotton may be molded by the operator to the correct external shape. If the tibia and fibula are removed in addition to the knee joint and the femur, reconstruction is carried out along the same general lines. Rounded ends covered by cotton on the dowel inserted into the lower leg may articulate with the rounded end of the distal portion of the dowel substituted for the femur.

A single piece of dowel may be used for both the lower and the upper portions of the leg. In this case the dowel is partially cut through and bent. Stabilization of both the upper and the lower portion of the leg is thus provided. The extremities may be placed in a position of flexion from forty-five to ninety degrees. No joint movement is obtained.

The *humerus* may be removed by a variation of this technique.

3. REMOVAL OF THE BONES OF THE FOOT. An incision is made posteriorly through the skin and the superficial fascia from a point about one centimeter above the tibio-astragalar joint around the heel and along the sole of the foot in the midline as far as the proximal portion of the metatarsal bones. After the skin flaps have been freed by blunt dissection over the ankle joint and over all aspects of the foot, the ankle joint is incised. A scissors cut carried around all aspects of the tibio-astragalar joint permits disarticulation of the foot. Over the lateral, medial, dorsal and plantar surfaces of the everted foot, blunt dissection frees the skin, deep fascia, and adipose tissue but leaves the musculature and deep fascia attached to the bones. Dissection is carried as far as the metatarso-phalangeal joints, which are then incised. The bones of the foot are freed in one piece from the distal end of the metatarsal bones.

After the removal of the intact specimen, the phalanges remaining in the foot are apt to assume a fan-shaped position. This condition may be corrected by the insertion of a small amount of plaster across the proximal ends of the phalanges in the depth of the skin pocket made by the removal of the

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specimen. The toes should be held in their normal positions until the plaster has hardened. A small section of dowel is now wrapped in sheets of cotton for insertion into the skin pocket. Again the shape of the intact foot is used as a guide in reconstruction. The posterior incision is sutured by the usual "baseball stitch," or, if particularly careful work is desired, by a subcuticular stitch.

4. EXAMINATION OF JOINT CAVITIES. The knee joint may be opened by a semi-circular incision from one condyle of the femur to the other. After the incision has passed through the patellar ligament, the patella is dissected back and the knee bent forcefully until the joint is exposed. Other joints in the body may be opened in similar fashion. In the examination of the cavities and surfaces of joints, the synovial membranes are viewed, and the presence of bodies (joint mice) and erosions on the articular surfaces are noted. The entire knee joint may be removed with the upper ends of the tibia and fibula and the lower end of the femur when more careful examination is desired.

5. VERTEBRAL COLUMN. The body is placed in prone position. The vertebral column is then exposed by the same technique used for the removal of the spinal cord in the adult (*cf.*—p. 95). Saw cuts are carried on each side of the vertebral column through the ribs close to their roots and through the sacroiliac joints.[1] By the method of Schmorl the cervical portion of the spine is freed by lateral saw cuts.[2] Chisel cuts next free the bone around the foramen magnum so that the entire spine may be freed in one piece. After removal of the spine a careful external examination is made. The spine is then sawed through its entire length with an electric saw in a median plane in the sagittal direction. The intervertebral discs with their three constituents, the nucleus, the annulus, and cartilage are now clearly seen in their relations to the vertebral bodies. The vertebral canal may be examined after the spinal cord has been removed.

If microscopic study of a bone is desired, a hand saw should

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be used in the cutting of the specimen to the correct size. A motor driven saw forces bone dust into the spongy tissues.[3]

REFERENCES

1. Beadle, Ormond H.: The Intervertebral Discs. Medical Research Council, Special Report Series, No. 161. London, His Majesty's Stationery Office, 1931.
2. Schmorl, George: Archiv und Atlas der normalen und pathologischen Anatomie. Leipzig, George Thieme, 1930.
3. Wagoner, G., and Nuckols, H. H.: A Comparative Study of Various Techniques for Preparing Bone Specimens for Museum Presentation, J. Tech. Methods, 14:35, 1935.

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CHAPTER X

AUTOPSY TECHNIQUE FOR SPECIAL CASES

1. METHOD OF WINDHOLZ. Windholz describes a modification of the usual primary incision for use in comparative pathologic-anatomic and roentgenologic studies.[1] Beginning at the acromial third of the left clavicle, the incision passes toward the right over the anterior surface of the right clavicle to a point approximately twelve to fifteen centimeters lateral to the sterno-clavicular joint. It is then carried in a curve through the musculature of the chest wall to the middle of the right axilla. In the execution of this incision, the right arm of the body must be abducted. From the middle of the right axilla the main incision passes in the mid-axillary line along the lateral aspect of the body through the skin and subcutaneous fat to the anterior superior spine of the ilium, whence it is carried above Poupart's ligament to the symphysis pubis. The clavicles are then freed from above and luxated. Now the abdominal cavity is opened from the line of the skin incision by a cut beneath the arch of the ribs through the abdominal musculature and the peritoneum. The peritoneal cavity is opened to the symphysis along the line of the primary incision. The height of the diaphragm is next determined. The thorax is opened by the costotome from below upward in the line of the primary incision. The attachments of the diaphragm and the ligamentum teres of the liver are severed. Raising the thoracic wall on the right, the operator severs all attachments to the mediastinum. Likewise, he divides all connections with the muscles of the neck. When the anterior thoracic wall has been separated from its connections as far as possible toward the left, the ribs on the left side of the body are divided subcutaneously by the costotome from below upward in the mid-axillary line. Now the operator may draw the entire anterior wall of the body: skin, musculature, sternum, and attached ribs, to the left side

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of the body, and divide any connecting muscles. This performance will yield a better view of the viscera than can be obtained by any other method.

Should the operator desire accurate localization of topographic relationships of the thoracic organs, he may follow another suggestion of Windholz. Before the organs are disturbed further, the inner surfaces of the ventral portion of the ribs and the adjacent borders of the sternum are carefully cleaned and then painted with a dye. A concentrated solution of gentian violet in ten per cent gum arabic is a successful agent, for it does not diffuse into the tissues nor rub off during the later handling of the organs. Now the operator returns the entire anterior wall of the body to its original position, and by means of light pressure makes contact between the bony structure of the thorax and the viscera. When the thoracic wall is again removed the markings of the ribs and sternum are seen on the anterior surfaces of the lungs, the anterior mediastinal structures and the liver. From these impressions the topographic relationships of the organs to the bony structures of the anterior thoracic wall may be reconstructed.

The Windholz method of exposure of the organs lends itself to a number of comparative anatomic and roentgenologic studies. It is particularly suited to examination of the lungs, since it exposes in clear view the lateral and apical portions, which are generally neglected by other techniques. The organs may be removed by any one of the usual methods.

2. METHOD OF LECOUNT. Lecount recommends, in suitable cases, the examination of the organs of the trunk from behind, according to a modification of the method originally attributed to LeTulle.[2] This method is used after the body cavities have been exposed in the usual manner and the neck organs have been freed. After severing the structures of the neck at the root of the neck, the operator lifts the right lung out of the thorax and inserts the point of the knife close to the spine on the right side at about the level of the first thoracic vertebra. The incision is carried forward and obliquely across the neck above the mouth of the thoracic duct so that the duct remains

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attached to the viscera. The diaphragm is then freed from the thorax on each side. Now the thoracic organs are severed from all connections with the vertebral column by cuts which pass as close as possible to the vertebra. Raising the thoracic organs vertically, the operator draws them gradually toward the pelvis while he frees the posterior attachments. As the organs are drawn toward the pelvis they are turned down and stretched in that position on a pan lifted across the thighs. Now the attached abdominal viscera are freed from the spine until the common iliac veins, as yet uncut, come into view. The operator must exercise special care to cut close to the spine where the crura of the diaphragm are attached, in order to avoid opening the receptaculum chyli. Now all the thoracic and abdominal viscera, presenting their posterior surfaces, have been drawn downward and placed in the pan on the thighs. The viscera remain attached to the pelvic organs which, still unsevered, lie in their normal positions in the pelvis.

The order of examination is as follows: the thoracic duct and its abdominal cisternae, the azygos veins, the inferior vena cava, the hepatic, iliac, renal and ovarian or spermatic veins, the adrenal glands, the kidneys and ureters, the peri-aortic and iliac lymph glands, the aorta and its branches below the diaphragm, and smaller structures such as the celiac ganglia. The esophagus is then dissected free and turned caudad. Then the iliac arteries and the aorta are dissected free and turned cephalad. The examination, continuing from the posterior approach, commences with the tracheo-bronchial lymph glands, the trachea and the main bronchi. The pulmonary artery and veins and the bronchi are opened as far into the lungs as is desired. The left auricle and the pulmonary veins are opened and examined. A median incision in the inferior vena cava is continued up through the back of the right auricle into the superior vena cava.

The examiner now turns to the abdominal organs. Slipping the fingers of his left hand from the right side through the foramen of Winslow, he severs the inferior vena cava, which is uppermost. Having thus exposed the hepatoduodenal ligament,

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he now examines the bile ducts, the portal vein and its branches, the hepatic artery, the lymph glands about the bile ducts and about the pancreas. The gall bladder, the bile ducts, the pancreas, and the pancreatic ducts, are sectioned and examined.

Leaving almost all important connections intact, the operator returns the organs of the thorax and abdomen to their respective body cavities. The organs may now be examined and removed by any of the usual routine postmortem techniques. This method of LeCount not only facilitates the examination of the large blood vessels and their branches, but also permits minute study of thrombosis of the iliac and ovarian veins or embolism or thrombosis of the mesenteric, renal, or portal vessels.

The following technique, similar in part to LeCount's method, may be of occasional value to the pathologist. The thoracic and abdominal organs, freed from all attachments to the vertebral column according to the procedure described above, are drawn forward in such a way that their posterior surfaces present over the thighs. Before freeing completely the pelvic organs, the operator returns the abdominal and thoracic organs to their cavities. A single specimen, consisting of the thoracic, abdominal and pelvic organs, may then be removed and placed on a platter for further dissection. This method is sometimes adaptable to the examination of infants, or of adults in instances of thrombosis or widespread tumor metastases. The organs are either freed and sectioned one at a time after their connections have been studied, or sectioned in topographic units.

3. THE RESTRICTED POSTMORTEM EXAMINATION. When restrictions are placed on the extent of the examination, the ingenuity of the operator is called into action. In some hospitals, peculiar restrictions are quite common, and organs are removed through the anus or the vagina. This practice should be discouraged, since it yields little information. The most frequent restriction specifies that the primary incision be limited to the abdomen. In most instances, however, all organs and structures which can be reached through this incision may be removed. When the examination is so limited, two types of

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primary incision may be used. The usual midline incision begins at a point just below the xiphoid process and passes downward to the left of the umbilicus and thence to the symphysis pubis. The exposure so afforded may be enlarged by a transverse incision of the abdominal muscles from within at several different levels. The abdominal cavity may be opened more simply by means of an inverted U incision (Fig. 3), the dome of which reaches a point just below the xiphoid process. The two arms pass down the lateral borders of the abdominal wall. The resulting flap is turned back over the genitalia and the contents of the peritoneal cavity come into view.

After the abdominal organs are removed, the diaphragm is cut away. The contents of the thoracic cavity are first palpated from below and then removed. This procedure is accompanied by considerable danger to the beginner, since the operative maneuvers are not guided by the eye. Long obstetrical gloves which reach the elbows should be worn, and care should be used to prevent accidental cutting of the operator's hands. Before the heart and lungs are removed, two strong ties are placed immediately above the heart around all structures from the mediastinum down to the vertebral column. This procedure is designed to prevent the emptying of the contents of the trachea, esophagus and great vessels into the body cavities. The body may be embalmed more easily if the great vessels are tied.

4. POSTMORTEM EXAMINATIONS UNDER UNUSUAL CONDITIONS. The pathologist may be called upon to perform an autopsy in a private home or in an undertaker's embalming room. In time of war, or in scientific field expeditions, autopsies may be performed under primitive conditions. With a little dexterity, complete examination can be carried out in a bed room or, as has been the case, in an open field in Africa. An ordinary kitchen table, a bed, a door lifted from its hinges for the purpose, or even a coffin may serve as an autopsy table. It is important to warn the undertaker not to embalm the body before examination, since embalming alters the gross appearances, and interferes with the performance of tests for certain poisons.

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The small amount of equipment needed can be carried conveniently in a large leather valise. This should contain a rubber bag for the transportation of organs removed at autopsy. A few knives and scissors of various types, a saw, a costotome, a chisel and steel hammer, a sponge, plenty of gauze if obtainable, a number of clamps, a needle, and a ball of string take care of the basic requirements. It is important to clamp and tie off structures wherever possible, to prevent spilling of blood, intestinal contents, or exudate. A waterproof cloth and newspapers are used to protect the rugs, floor, or furniture. A few pails, a basin, water, and a piece of wood for the support of the head, can be procured usually without difficulty. An alcohol lamp, a platinum loop, culture media in test tubes, clean slides, a sterile syringe, a sterile test tube for the collection of blood and a jar containing ten percent formalin solution complete the necessary equipment.

It is important that no trace of the autopsy be left in the home after the examination has been completed. In homes where fireplaces or coal stoves are available it has been recommended that ground coffee be thrown on a shovel full of burning coals to suppress the odor occasioned by the autopsy.[3] The ingenuity and tact of the pathologist are important in the successful performance of a private autopsy, particularly when relatives or undertakers are present.

5. THE MEDICOLEGAL POSTMORTEM EXAMINATION. The medicolegal postmortem examination is carried out in the same manner as the routine hospital examination. It differs from the ordinary autopsy only in the special legal ends to which the findings are applied. The hospital pathologist may on occasion be called upon to perform a medicolegal autopsy. For toxicologic procedures or for the interpretation of findings such as gunshot wounds, he should consult the specialist. The following discussion of the medicolegal autopsy is designed merely to acquaint the young pathologist with some of its special problems. For a full discussion of the importance and interpretation of these problems, he should consult books dealing with the field of legal medicine.[4,5]

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Medicolegal autopsies are usually performed for the investigation of deaths caused by violence, by poisoning, whether accidental, occupational or homicidal, and by injuries resulting from accidents. They include, moreover, the investigation of deaths occurring suddenly without adequate explanation. The first duty of the pathologist is to determine whether death was due to natural causes. If the pathologist is called in an official capacity to the scene of the crime he must view the scene of the death, the condition of the surroundings and the position of the body. It is wise to take as many photographs as possible of the room, the position of the body, the outside of the body and any portions of the body showing important changes.

The external examination of the body proceeds as in the ordinary autopsy with inspection of all body surfaces. The skin over the neck is examined particularly for evidences of strangulation. The presence of wounds caused by fire arms is sought and the skin about such wounds is examined with the aid of a magnifying glass, when necessary, for evidence of powder marks or burns. The presence of cuts, stab wounds, abrasions and lacerations, is noted. The external genitalia are examined with great care, particularly when rape is suspected. In such cases the perineum is inspected for evidences of lacerations, and smears are taken from the vagina and from the cervix of the uterus for microscopic search for spermatozoa.

The usual postmortem technique is then applied for the opening and exposure of the body cavities and for the removal of organs. Foreign bodies present in the larynx or edema of the glottis, may be of great importance in the explanation of sudden death. When intoxicated individuals die suddenly, a bolus of meat may be found tightly impacted in the larynx. The bronchi, opened carefully, are searched for foreign bodies. In cases of drowning, the contents of the trachea, bronchi and lungs are examined for foreign materials derived from the water.

Especial attention is paid to the gastro-intestinal tract,

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liver, kidneys and brain when poisoning is suspected. In every case in which the cause of death is not clear, material for toxicologic examination should be removed, properly preserved and sent to the toxicologist for study. The body should not be embalmed before the autopsy, since formaldehyde in the embalming fluid interferes with chemical tests for cyanide and several other poisons. The best results in toxicologic examination are obtained before putrefaction sets in, since putrefaction interferes with tests for alkaloids. All material for toxicologic examination should be placed in clean glass containers equipped with glass covers. Metal covers should not be used. The weights of the organs are necessary for quantitative calculations. Stomach contents are best removed after the ends of the stomach have been tied and the organ removed from the body. From the stomach, which is then opened, the contents are poured directly into the glass container. The contents of the intestinal tract are removed in similar fashion. The viscera must not be contaminated by the stomach and intestinal contents.

For the best routine work in toxicology, the pathologist should send to the toxicologist the contents of the stomach and of the intestines, portions of the liver, brain, lungs, kidneys, heart muscle, spleen, bones, hair (when possible finger nails) and samples of blood and urine. If death has been caused by drowning in a swimming pool, a sample of blood is obtained from the right auricle and one from the left auricle. These are placed in separate bottles and properly labelled. A sample of the water in the swimming pool is also obtained, since the chemical test for drowning under such conditions depends upon the chloride content of each heart chamber.[6] If the body has been embalmed, the pathologist should obtain a sample of the embalming fluid for the toxicologist, who may determine whether the poison found in the body was present in the embalming fluid. The toxicologist examines the various materials for the following poisons (Gettler):

1. Contents of the stomach and of the intestines—acids,

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alkalies, ammonia, nitrates, chlorates, sulphides, and so forth.

2. Brain—alcohol, alkaloids, benzol, chloroform, ether, veronal group (diethylbarbituric acid).
3. Liver—fluorides, metals, oxalic acid, sulphonal (diethylsulphondimethyl-methane), veronal group.
4. Kidneys—mercury and other metals.
5. Blood—carbon monoxide and other gases.
6. Bones, hair and nails—arsenic, lead, radium.
7. Lungs—inhaled gases.
8. Urine—arsenic, mercury, sulphonal, veronal group.

All material for toxicologic examination should be put into suitable containers as described above, properly labelled and sealed and then sent to a toxicologist of experience. In all cases in which death is caused by accident the brain or spinal fluid should be examined for evidence of alcohol. The discovery of an alcoholic content of the brain or of the spinal fluid of more than twenty-five hundredths percent indicates that the subject was intoxicated just before death (Gettler).

If death has occurred suddenly, and without apparent reason, a careful postmortem examination should reveal the cause. Since poisoning is always a possibility, suitable material is taken for analysis. Bacteriologic examination of the blood and of the contents of important organs and structures, such as the intestinal tract and lungs, must be performed. In adults of middle age rupture of the heart following coronary disease may be found. Sudden death may be caused by cerebral hemorrhage or the rupture of an aneurysm. In the last fifteen years pulmonary thrombosis and embolism have increased in frequency as causes of sudden death in various parts of the world. Sudden death in young children may be brought about by fulminating infections caused by the streptococcus, the meningococcus, the dysentery bacillus, and other organisms. Deaths resulting from the faulty administration of an anesthetic occur most frequently in childhood. In recent years, as a parallel to the increase in general knowledge

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of allergy and also the great increase in the use of foreign proteins in therapeutic and diagnostic procedures, sudden death following the administration of foreign proteins has been observed to occur with increasing frequency. The diagnosis of status thymico-lymphaticus as a cause of sudden and unexplained death in childhood is now less commonly resorted to than in the past. Complete postmortem examinations in such cases should reveal an adequate cause for death.[7]

REFERENCES

1. WINDHOLZ, F.: Method of Postmortem Examination with Comparison with X-ray Findings, Virch. Arch. f. path. Anat., **277**:658, 1930.
2. LECOUNT, E. R.: Suggestions Regarding Postmortem Technique, J.A.M.A., **75**:1611, 1920.
3. MALLORY, F. B. and WRIGHT, J. H.: Pathological Technique, Eighth Edition, page 579, Philadelphia, W. B. Saunders, 1924.
4. PETERSON, F., HAINES, W., and WEBSTER, R. W.: Legal Medicine and Toxicology, Second Edition, Philadelphia, W. B. Saunders Co., 1923.
5. The Medicolegal Necropsy: Edited by Thomas B. Magrath, Baltimore, Williams and Wilkins Co., 1934.
6. GETTLER, ALEXANDER O.: Chapter on "Toxicology in the Medicolegal Necropsy," page 50, in The Medicolegal Necropsy, Baltimore, Williams and Wilkins Co., 1934.
7. BOYD, E.: The Weight of the Thymus Gland in Health and in Disease, Am. J. Dis. Child., **43**:1162, 1932.

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CHAPTER XI

SPECIAL PROCEDURES

1. Restoration of the body. First, the base of the skull is carefully dried and cleaned. Then the cut ends of the carotid arteries are tied for the convenience of the undertaker when he embalms the body. A plug of cotton is placed in the foramen magnum. A thin layer of plaster is poured over the base of the skull to fill up all defects made during the autopsy and to give sufficient weight to the skull. The skull cavity is then filled with absorbent cotton and the calvarium is replaced. If the wedge-shaped incision has been used in the removal of the calvarium, the structure will be held in place. The calvarium may be fastened more firmly by ligatures passed through drill holes bored on each side of the saw line. The cut ends of the temporal muscles are connected by sutures, which give additional security to the calvarium. If, at the time of the removal of the calvarium, a triangular projection of bone has been left in the occipital region it will now assist in holding the calvarium in position.

Pulling the scalp back over the calvarium, the operator closes the line of incision by one continuous "baseball" suture. The curved autopsy needle, passing from the inner surface of the skin outward from one side to the other, penetrates the skin about one centimeter from the cut edge, in stitches that occur at intervals of one centimeter. The curved needle is held by the right hand and the slack of the string in the left. After each new insertion of the needle has been made, the string held in the left hand is drawn upward with sufficient force to pull the sutured skin surfaces tightly together.

The hair is now carefully cleaned and combed over the line of incision. If the calvarium has been replaced securely and if the anterior saw cut has been made above the hair line, no deforming ridge will be noticed over the forehead.

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The body cavities are dried and cleaned and the external openings (anus, vagina) are plugged with cotton. The shape of the neck is restored by the insertion of enough cotton to bring about the proper external appearance. If desired, the tongue may be returned to its position and held in place by sutures. The sternum is then fastened in place by interrupted sutures which pass through the intercostal muscles. The body

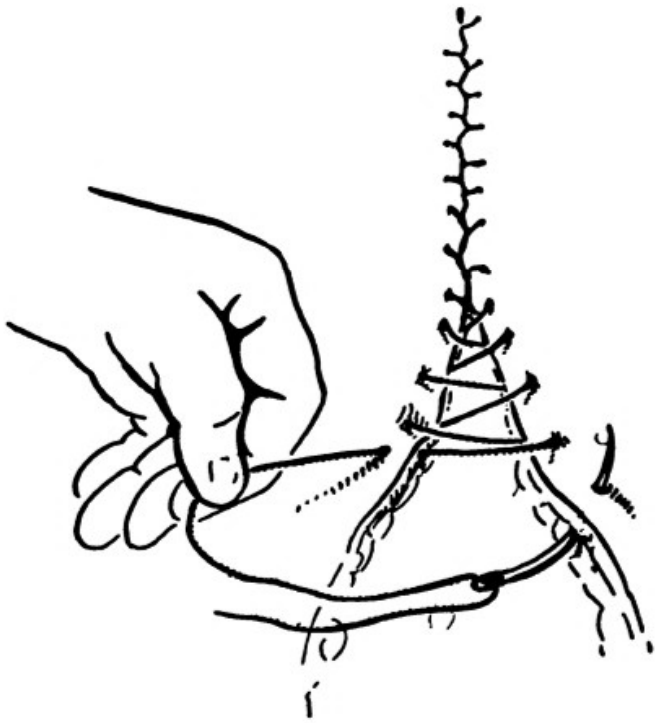

FIG. 28. Reconstruction of the body. The line of incision is repaired by a "baseball stitch". The curved autopsy needle passes from the inner surface outward. The string is kept taut by the left hand.

cavities are filled with sawdust sufficient in amount to restore the external contour of the abdomen. The operator may then repair the Y-shaped incision by means of a continuous "baseball stitch" such as he employed in closing the scalp incision (Fig. 28). The suture may begin at the symphysis pubis or at the end of either one of the upper arms of the Y. A separate continuous suture must be used for one of the upper arms. The strings which have been attached to the cut

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ends of the innominate, left common carotid and left subclavian arteries are drawn out through the line of incision before it is completely repaired, and are permitted to hang over the outside of the body. Strings attached to the iliac arteries, which have been ligated, are drawn through the line of closure in a similar fashion. This procedure enables the undertaker to find the large vessels easily.

If bones have been removed from the extremities or if the vertebral column has been taken out, the defects may be repaired according to the technique described on page 131, by the insertion of pieces of wood of suitable size. If additional incisions have been made in the skin in regions not customarily the site of an autopsy incision, they are repaired by subcuticular sutures which leave but a thin line visible. After the body has been washed carefully by luke-warm running water and the surfaces have been dried, all sutures may be covered by strips of adhesive plaster. The body is then dressed in a shroud and returned to the cold room.

In many institutes of pathology, it is customary to replace the organs into the body cavities after they have been sectioned. Indeed, this is a procedure often necessitated by law. The organs are freed from all blood, exudate, fecal and fluid contents and placed in the floor of the abdominal and thoracic cavities. The cut brain should be placed in the thorax since, if the brain is returned to the cranial vault, the soft tissue may leak through the suture line. After the organs have been replaced they are covered by sawdust for the absorption of moisture. In order to delay putrefactive changes, the operator may dip the viscera into a five percent chloral hydrate solution before returning them to the body. Then, after draining the fluid from the organs, he may place them with whatever chloral hydrate they retain, in the floor of the thoracic and abdominal cavities.

Weinmann has given the following legal opinion in reference to the removal and the return of organs: "If a physician performs an autopsy which he is legally authorized to do, either by the consent of the persons entitled to sepulture or

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by virtue of statutory authority, including direction from a coroner, such physician cannot legally remove and retain portions of the body unless such procedure is essential for determining the cause of death or for the determination of some other reason for which the autopsy was ordered or permitted."[1]

2. THE AUTOPSY PROTOCOL. The protocol is a clear, complete and objective description of the findings at postmortem examination. It is a permanent record of all observations made both at the time of the gross examination and in subsequent bacteriologic, histologic and chemical studies. The opinion of the operator is found only in the list of anatomic diagnoses and in the summary appended to the protocol. Descriptive sentences should be complete and grammatical. The final protocol should be typewritten and added to a series which, when complete, will be bound. The descriptions of the operator's findings are best dictated as he makes them. When such an arrangement cannot be made, all important notes should be dictated to an assistant who fills out a printed form prepared for this purpose. If no assistant is available the operator may record important notes and measurements on a blackboard conveniently within reach. If the protocol has not been dictated during the performance of the autopsy, the operator must write or dictate the protocol immediately after the close of the gross examination. Delays in recording the findings in complete form lead to untrustworthy reports. The description of the gross findings and a list of the gross anatomic diagnoses are typed immediately. The results of the microscopic, bacteriologic and chemical examinations and the final summary are added at a later time.

The operator must keep in mind the purpose of the protocol. It is a permanent record to which clinicians, pathologists, and medical students (and on occasion, attorneys) may refer. The observations recorded in the protocol may serve as a basis for further research. Inaccurate statements, ambiguous descriptive terms, omissions of important positive or negative findings, and personal opinions of the operator detract from

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the value of such a permanent record. The description of pathologic changes should be so free from "leading" diagnostic terminology that any other pathologist may, on reading the protocol, reach an independent diagnosis.

All weights and measurements should be recorded in the metric system. An organ is described in regard to its size, shape, consistency and color. Description of a fluid includes notations on the amount, density, color, odor, transparency and, when indicated, chemical reaction and specific gravity. The circumference, thickness and appearance of the walls and the character of the contents are included in a description of hollow viscera. Care should be used in the selection of the exact descriptive terms for the color and the consistency of an organ. Comparative measurements such as "the size of a hen's egg" should not be used. A simple study of the size of one hundred hen's eggs will readily convince the young pathologist of the capriciousness of such likening.

In the description of findings it is well to follow the anatomic landmarks of a given organ. In the lung, for example, the number of lobes, the pleural surfaces, the surfaces made by cutting, the bronchi and bronchioles, the pulmonary vessels, the lymph glands at the hilus, may be described in turn. Important pathologic changes receive more attention than do descriptions of normal anatomic structures. The operator is warned against too much description of minute changes, to the neglect of more important alterations.

The protocol should follow a definite outline, suitable headings of which introduce each new portion. The descriptions of microscopic findings follow a similar outline. The finished protocol in typewritten form contains the following parts:

1. *The Title Page.* At the top of the first page the following items are found: name of the pathologist, name of the patient, age, sex, date, hour, number of hours postmortem and restrictions. Beneath this is the clinical diagnosis. The body of the first page contains a list of the final diagnoses, listed in order of their importance. They may be divided into two parts: the first group of

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diagnoses contains the primary and contributory causes of death; the second group lists the incidental findings. All pathologic changes, no matter how minute or apparently unimportant, should be listed in this second group. At the bottom of the first page are listed the results of bacteriologic and possible chemical examinations.

2. *The Abstract of the Clinical History.* Prepared by the clinician who cared for the patient, this summary should not exceed one typewritten page in length. The abstract includes significant notes on the family history, past history, present illness, course of the disease and the results of important laboratory and roentgenologic examinations.
3. *The Body of the Protocol.* This portion is divided into two parts; the records of the gross and those of the microscopic findings. The gross findings, in a definite order, include a description of the primary incision, the body cavities, the section of the various organs, the removal and section of the brain and the removal and section of the spinal cord. If the extremities have been examined or removed, they are described here. The second part consists of the descriptions of histologic preparations made from the various organs of the body and the brain, from the spinal cord, and from the skeletal system.
4. *The Summary.* The summary is one of the most important parts of the protocol. Forcing the pathologist to review the clinical history and the findings at postmortem examination, it leads to a careful consideration of all problems presented in the individual case. The summary should begin with a short statement of the salient clinical aspects. The next paragraph includes briefly the important pathologic changes observed by the operator. The final paragraph contains a discussion of the correlations which may be made between the clinical and the pathologic findings, and a definite state-

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ment of the still unanswerable problems noted either during life or at the postmortem examination. It is to this portion of the protocol that the pathologist and the clinician may turn for the discovery of unsolved problems and for stimulation to further research. The pathologist should recognize that the postmortem examination may not provide the answer to all questions in every case: the value of the summary lies, indeed, to a great extent in the emphasis of this fact. The summary is a grateful instrument to the clinician who, in turning to it directly, may discover whatever information he is seeking without studying the entire protocol. In all indicated cases the summary should contain a review of the important literature bearing upon the subject. The references to such literature should be listed at the end of the protocol.

After the protocol has been completed it is corrected and signed by the head of the laboratory. The diagnoses are listed in a suitable index. If facilities for photographic work are available, pictures of gross and microscopic specimens should be made whenever advisable and filed with the protocol. Care and experience are required for the correct selection of specimens for photographic purposes. A good sharp photograph appended to the protocol is often of greater value than several pages of description. Discussions of the best photographic methods for use in the autopsy room are given by Harding[2] and by Schmidt.[3]

The following outline is a convenient guide for note-taking in the postmortem room and for the dictation of the protocol.

AUTOPSY NO. Performed by: Date: Hour:
Hours Postmortem: Restrictions: Service: Hosp. No.:
Name of Patient: Age: Sex: Color:

CLINICAL DIAGNOSES:
Body Length: Development: Nourishment:
Rigor Mortis:
Postmortem Lividity: Edema: Skin: Lymph Nodes:
Hair: Ears: Nasal Passages: Eyes: Pupils:

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External Marks:
Primary Incision: Subcutaneous Fat: Muscles:

PERITONEAL CAVITY: Fluid: Adhesions:

PERITONEAL SURFACES: Positions and Relations of Organs:
Appendix:
Height of Diaphragm: L. R. Mesenteric Lymph Nodes:

PLEURAL CAVITIES: L. R. Surfaces: Position of Lungs:

MEDIASTINUM: Thymus: Lymph Nodes:

PERICARDIAL CAVITY: Surfaces: Fluid:
Heart: Weight: T.V. P.V. M.V. A.V.
Contents:
Myocardium: L.V. R.V.
Lungs: Weight R. L.
Spleen: Weight:
Gastrointestinal Tract:
Pancreas: Weight:
Liver: Weight:
Gall Bladder and Ducts:
Kidneys: Weight R. L.
Thickness Cortex: Capsule:
Adrenals:
Bladder:
Genitalia:
Aorta and Arterial System:
Large Veins:
Organs of Neck:
Brain: Weight:
Skull and Sinuses:
Middle Ears:
Naso-pharynx:
Accessory Sinuses:
Bone Marrow:
Spinal Cord:
Skeleton:

3. THE CLINICAL-PATHOLOGIC CONFERENCE. Conferences should be held at regular intervals in all hospitals. A number of methods of presentation have been tried.[4] Correlating the clinical and pathologic findings, these occasions are impelled by two main purposes: the open discussion of questions arising from the death of a patient; and the constant education of the members of the hospital staff. Conferences should be open as

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well to all members of the medical profession and to medical students.

Richard Cabot introduced, more than twenty-five years ago, a particularly interesting, stimulating and valuable type of conference.[5] At the beginning of the exercise Dr. Cabot was given a mimeographed abstract of the case record of a patient who had died and about whom Dr. Cabot knew nothing before the exercise. Copies of this case record were given to each member of the audience. Then Dr. Cabot, reading the record aloud, commented on the history, the physical and laboratory examinations and the roentgenograms. On the basis of all findings given to him, Dr. Cabot made a diagnosis and justified it. The pathologist then described the findings at autopsy and gave, when indicated, gross and microscopic demonstrations. Aiming at unequivocal diagnoses, Dr. Cabot earnestly attempted to correlate clinical and pathologic observations, in order to improve not only his own diagnostic acumen but also that of his audience.

A weekly clinical-pathologic conference may be modeled on the following lines. The exercise is conducted by the hospital pathologist. After the case history has been presented by the house officer who cared for the patient, discussion is begun by the physician or the surgeon in charge of the particular service, and continued by any interested person in the audience. Main emphasis is placed upon the diagnostic problems presented and upon the efficacy of therapeutic procedures. Now the pathologist presents a brief description of the gross and microscopic changes noted on postmortem examination, and advances a correlation of the important clinical and pathologic findings. Open discussion then follows. Minute histologic changes and theoretical questions of interest only to a group of pathologists are not in order.

The report of the pathologist is a summary of the objective findings in the case. His is not the task to hide or excuse errors in clinical judgment or therapy. On the other hand, the pathologist must not abuse the privilege of his position. The success of the conference depends in large part upon the

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dispassionate recital of all clinical and pathologic observations made on a given patient.

The weekly meetings constitute a clearing house for new ideas in medicine. The pathologist should prepare a review of the literature on the subject at hand and advise the clinicians to present the advances in their fields. If the doctors who participate in such conferences give freely of their ideas and experience, they stimulate members of the audience to make investigations toward the settlement of disputed questions. Conference cases should be of varied types. Common causes of death should be discussed frequently for the very reason that they are common. From time to time rare disease conditions and peculiar congenital anomalies may be presented, particularly when such conditions can be recognized and treated during life.

4. THE STUDENT AUTOPSY CONFERENCE. It is desirable for the student to see as many autopsies as possible during his course in general and special pathology.[6] While taking clinical work on the wards of the hospital in the last two years of his medical course, the student should be permitted to observe the necropsies on all patients who die in the hospital and are examined. In general, the smaller the group of students at the examination the greater amount gained by each individual.

The following method of teaching of students at autopsy has been pursued successfully at the Harvard Medical School. The class is divided into groups of twelve students, one of whom in each section acts as secretary. (In medical schools where the classes are small, groups of six men are preferable). Assignments to postmortem examinations take precedence over lectures and class room work. The various duties are assigned in rotation so that each man has an opportunity in the course of the school year to fulfill all obligations connected with the postmortem examination. The men are provided with Zenker's solution and, in special cases, with other fixatives. At the time of the postmortem examination the students witness the various procedures demonstrated by the

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instructor. After the organs have been sectioned, students may examine the organs. Sections for microscopic study are selected by the instructor and given to one student for fixation. The various duties are assigned as follows:

One man makes an abstract of the clinical history. It is understood by both instructors and students that detailed clinical findings are not of great moment here, since the students have not yet studied physical diagnosis and clinical medicine. A second student makes a description of the gross anatomic findings at the postmortem examination. He writes a protocol modeled upon the protocol written by the pathologist. Three students, using in most cases a hematoxylin-eosin stain, make microscopic preparations of the more important organs. Although one man writes a description of microscopic preparations, all members of the group are expected to examine the slides before the conference. To one student is assigned the task of studying the general considerations of the disease in question. He is expected to correlate as far as possible the clinical signs and symptoms with the anatomic findings and the probable alterations in function.

After a suitable period of time, usually about three weeks, an instructor holds a conference lasting one hour with the members of the group. Informality is the key note of the conference; both instructor and students interject questions and comments. A definite order is followed, however, and, as far as possible, the students are expected to conduct the program. After an abstract of the clinical history has been given, the findings at the postmortem examination are described. Now the student who has written a description of the microscopic preparations presents his observations, preferably with the aid of a micro-projection apparatus. The student may point out the various microscopic changes on the screen and answer questions from his colleagues or from the instructor. After the general aspects of the disease process have been discussed by the man assigned to that task, the instructor concludes the conference with a summary of the important features of the exercise.

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REFERENCES

1. WEINMANN, G. H.: A Survey of the Law Concerning Dead Human Bodies, Washington, D.C., National Research Council, bull. 73, p. 90. (See also Schultz, Oscar T., pp. 7-23 in The Medicolegal Necropsy, Baltimore, Williams and Wilkins Co., 1934.)
2. HARDING, F. R.: (a) Backgrounds for Pathologic Specimens, J. Biol. Photographic A., 2:28, 1934.
   (b) Simple Methods of Photographing Gross Specimens, J. Biol. Photographic A., 3:131, 1935.
3. SCHMIDT, L., and HAULENBEEK, J. B., A Method of Photographing Gross Specimens, J. Biol. Photographic A., 1:76, 1932.
4. STEINBERG, B., Autopsies and The Hospital Staff Conference, Proc. Ann. Cong. Med. Educ. 1929, p. 55.
5. FITZ, REGINALD: Importance of Clinical-Pathologic Conferences in the Work of the Practitioner as a Teacher, J.A.M.A., 101:253, 1933.
6. MCCUTCHEON, MORTON: Method of Teaching Students Morbid Anatomy at Autopsy, J. Tech. Methods, 14:18, 1935.

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CHAPTER XII

POSTMORTEM EXAMINATIONS ON INFANTS AND CHILDREN

THE PECULIARITIES in the structure of the body and in the disease problems during early life demand important variations from the usual technique employed in the examination of the adult. As complete and systematic a necropsy should be performed on a fetus, a premature infant, a young infant or a child as on an adult. Since congenital malformations occur so commonly in early life, particular attention is directed toward the possible presence of structural anomalies in all parts of the body. In few fields of medicine is the pathologist so richly rewarded for careful postmortem examinations. There still remain numerous diseases of unknown etiology and pathogenesis. Metabolic and dietary disturbances give rise to pathologic changes which, in many instances, are poorly understood. A number of infections peculiar to early life bring about gross and microscopic alterations strikingly different from any seen in adult life. Of particular interest to the pathologist performing necropsies on the young is the rarity of cicatrices and other evidences of the repair of old disease processes; the lesion at hand most often represents the uncomplicated response of the body of the infant to the etiologic agent. Within recent years experimental work has yielded an explanation of certain pathologic sequences which previously were not well understood. It is now possible, for example, to recognize the early changes brought about by vitamin A deficiency.[1] To discover the metaplastic changes characteristic of this disease, the pathologist who performs necropsies on young infants and children must study routinely the epithelium lining the pelvis of the kidney, the trachea, the ducts of the pancreas and salivary glands, and epithelium from other parts of the body.

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1. EXTERNAL EXAMINATION. The body of the infant or child is examined by the same methods used on the adult. Loss of fluids, a common accompaniment of infections in early life, causes rapid changes in the skin. Alterations in the consistency of the skin and subcutaneous tissues are of particular importance in childhood. Malformations of the extremities, the spinal column, the anus, and other portions of the body may be recognized on external examination. Tuberculides in the skin often give the first clue to the presence of tuberculosis elsewhere in the body.

2. PRIMARY INCISION. The usual Y-shaped incision is suitable for autopsies on the young. Variations may be used on occasion. When the operator desires to examine the umbilical vessels more efficiently than the Y-shaped incision allows, he may employ the variation described on page 52. The upper arms of the Y-shaped incision, executed as usual, join at the xiphoid. A mid-line incision continued from that point descends over the abdominal wall about four centimeters and then divides to left and right. The two branches pass along the lateral borders of the abdominal wall as far as the crest of the ilium on each side. By turning back the inverted U-shaped flap over the genitalia, the operator may expose the umbilical vessels.

3. REMOVAL OF THE THORACIC AND THROAT ORGANS. The organs of the thorax and of the throat are removed *en masse*. After the sternum has been removed and the pleural and pericardial cavities inspected, the thymus is dissected free and removed from the body. The tongue and organs of the throat are freed as far as the suprasternal notch. If the operator finds no evidence of a tracheo-esophageal fistula he severs the esophagus and aorta by means of a transverse incision just above the diaphragm. He then frees the thoracic organs from their lateral and posterior attachments to the vertebral column and removes all the contents of the thorax with the throat organs. This method is recommended for two reasons. First, by retaining attachments, it facilitates further section of the organs, the smallness of which constitutes a source of difficulty

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in examination. Second, this technique preserves the vascular connections for the correct inspection of the ductus arteriosus.

The removed throat and thoracic organs, posterior surface upward, are placed on a platter. The esophagus presents an-

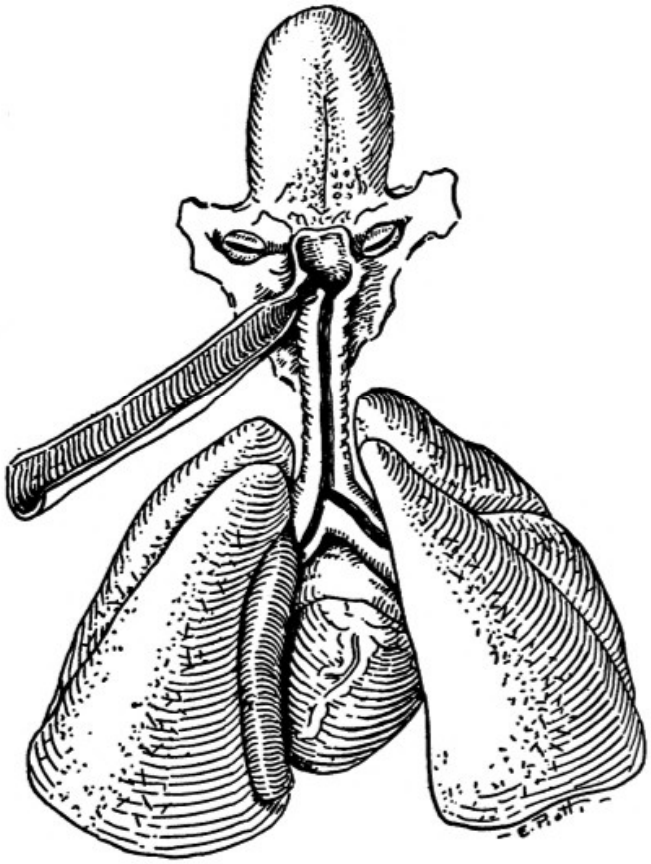

FIG. 29. Section of the throat and thoracic organs in postmortem examinations on infants and children. The organs, posterior surface presenting, have been placed on a platter. The esophagus, opened by a midline incision, has been dissected free from its anterior attachments and drawn to one side. The path of the midline scissors cut through the larynx, trachea and bronchi is shown. The tonsils have been incised.

teriorly and the tongue is directed away from the operator. The *esophagus* is opened along the midline by a scissors cut which is continued through the attached portion of pharynx. By means of careful scissors dissection the esophagus is freed from its connections to the trachea, the aorta and adjacent

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structures as far as the pharynx. Still attached to the pharynx, it is drawn to one side (Fig. 29). The position of the specimen is now reversed so that the tongue faces the operator. Inserting the lower blade of the scissors into the *larynx,* the operator makes a midline incision through the larynx along the membranous portion of the *trachea* and into each main bronchus. The mucosal surfaces of the larynx and of the trachea are inspected. Since the esophagus has been dissected away, the lymph glands lying at the bifurcation of the trachea and along the trachea and the bronchi, come into view. These glands often reach a very large size in certain lung infections, and press against the bronchi. The lungs may now be sectioned by a long incision which passes from apex to base down to the hilum of the lung, or by single incisions made in each of the lobes. Further dissection of the bronchi and the pulmonary vessels is reserved until the heart has been opened.

The heart is opened in the manner described for the adult, save for a few minor exceptions. When the incision through the pulmonary valve into the pulmonary artery is made, the point of division into the right and left branches of the pulmonary artery is located. If the *ductus arteriosus* is patent it will be recognized as a direct continuation of the first part of the pulmonary artery into the aorta beyond the bifurcation of the pulmonary artery. The ductus may be found by another method. After the arch of the aorta has been opened by a midline incision, the three vessels which leave the arch are identified. The mouth of the ductus in the wall of the aorta is located at a point obliquely opposite the exit of the left subclavian artery from the arch of the aorta.

If the ductus arteriosus does not appear to be patent, it may be tested by a fine hair-pin probe. The ductus arteriosus is closed gradually over a period of six to eight weeks after birth by a process comparable to endarteritis obliterans. During the process of closure, the lumen contains flaky chocolate colored material.

At birth, the portion of the aorta lying between the origin of the left subclavian artery and the entrance of the ductus

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arteriosus, is narrow. This portion (the isthmus), widening gradually, reaches the diameter of the aorta below the ductus after thirty days. The right ventricle outweighs the left at birth by thirteen per cent.

The heart is now carefully examined for anomalies in structure. Defects in the interventricular septum occur most frequently beneath the valve line but may be found at the mid portion of the septum or near the apex of the heart. The interauricular septum may be the seat of malformations (persistent ostium primum or ostium secundum). The *foramen ovale,* found in about the mid portion of the interauricular septum, is often present as a thin slit well covered by the auricular wall on each side. By means of slight manipulation, a probe may be inserted through what amounts to a functionally closed foramen ovale. The closure of the foramen ovale is not complete until several months after birth.

Pinhead-sized hemorrhagic spots found on the leaflets of the valves (most often on the leaflets of the venous valves), represent blood cysts of disputed origin. They probably indicate remnants of fetal vascularization of the valves.

The coronary vessels and the valves are examined as in the adult heart. By means of dissecting scissors the *bronchi, pulmonary veins* and *pulmonary arteries* are now opened in the manner described for the adult. The upper respiratory tract is always searched for foreign bodies, food, vomitus, and other materials which may be aspirated by the infant or young child. In the lungs of the newborn infant, amniotic sac contents may be found as a consequence of intrauterine asphyxia. Particular attention is paid to the possible presence in the larynx and trachea of diphtheritic membranes. Retropharyngeal abscesses and dissecting retroesophageal or retrotracheal inflammatory processes may be traced without difficulty since the connections between the organs of the thorax and the throat are maintained. Lymph glands at the hilum of the lung frequently provide a clue to pathologic changes within the lungs, as, for example, in tuberculosis. The mediastinum is often the seat of inflammation in instances of acute inflam-

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matory changes in the pleural cavities and the lungs.

The numerous gross procedures designed to ascertain whether the infant has breathed, are not recommended here since they are subject to great error. The tests which depend upon the presence or absence of air detectable on gross examination (float tests, and so forth), do not take into account the possibility of resorption of air from the lungs after the child has breathed for some minutes or hours. The most careful gross procedure used in the past, necessitates the ligation of the trachea before the removal of the sternum. The operator then places the lungs, or selected portions of the lungs, in water to determine whether they float. We recommend but two procedures: observation of the amount of pericardium covered by the medial borders of the lung; and more important, microscopic study of numerous portions of both lungs.[2]

4. EXAMINATION OF THE ABDOMINAL CAVITY. The umbilical vessels are examined first. Beginning at the umbilicus, the operator opens the *umbilical vein* with fine dissecting scissors and follows it along its course into the liver. He may prefer to dissect the umbilical vein for one-half its distance and then sever it. The remaining dissection is then carried out after the liver, still attached to the distal portion of the umbilical vein, has been removed from the body. After giving off several intrahepatic branches to the liver, the umbilical vein divides into two branches. The larger branch, joining the portal vein, enters the right lobe of the liver; the smaller communicates with the ductus venosus, which either enters the inferior vena cava directly or, more commonly, joins the hepatic vein just before the hepatic vein enters the inferior vena cava.

Because of the unique connection of the veins of the portal system and the veins of the systemic circulation with the external surface of the body during the early postnatal period, infection arising in the umbilicus may spread into the portal system or into the inferior vena cava by way of the umbilical vein. Dissection of the umbilical vein is, therefore, always continued into the portal vein and into the ductus venosus

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and the inferior vena cava (Fig. 30). The umbilical vein, closing gradually over a period of thirty to sixty days after birth, is replaced by a fibrous cord, the ligamentum teres. Small veins (the paraumbilical veins) which are often present throughout life in this fibrous cord, and anastomose with the portal vein, assume importance in instances of portal obstruction. Here they aid in the formation of a caput medusae be-

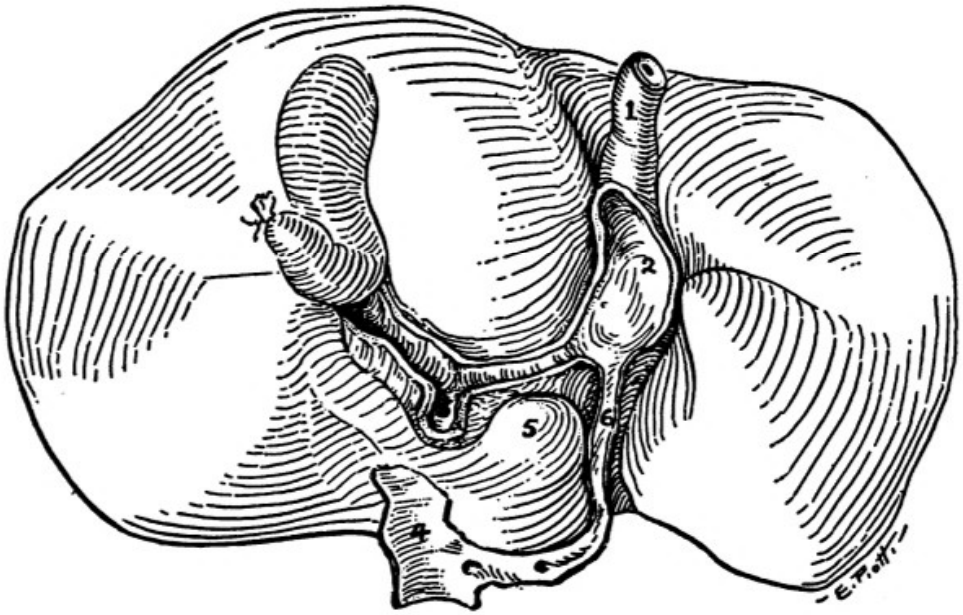

FIG. 30. Method of opening the umbilical vein, portal vein, ductus venosus and inferior vena cava in postmortem examinations on young infants: (1) unopened stump of the umbilical vein; (2) opened portion of the umbilical vein; (3) portal vein; (4) inferior vena cava; (5) caudate lobe of the liver; (6) ductus venosus.

cause of their communication with small veins in the skin around the umbilicus.

The ductus venosus lies in the fossa between the left lobe and the caudate lobe of the liver. Obliteration of the ductus is usually complete by the end of the second month after birth.

The operator may either open the *umbilical arteries* by fine dissecting scissors or expose their lumina by a series of transverse incisions. Infection sometimes spreads from the skin into the systemic circulation by way of the umbilical arteries, which are direct continuations of the hypogastric arteries. By

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the end of the second month after birth, the portions of the hypogastric arteries, extending from the sides of the bladder to the umbilicus, are obliterated and form the lateral umbilical ligaments.

The *urachus* is usually present as a fibrous cord coursing from the umbilicus to the dome of the bladder. It is examined by a series of transverse incisions or opened by fine dissecting scissors.

The *pelvic organs* are removed by the same technique employed in the examination of the adult. When the ureters are dilated, the cause of the obstruction may be found in the lower ends of the ureters just before they reach the bladder. Aberrant vessels crossing the ureter near the hilum of the kidney may cause obstruction. The ureteral orifices in the bladder are probed carefully. The posterior urethra should be removed with the organs of the pelvis. Malformation of the verumontanum characterized by the presence of valve-like structures constitutes an important cause for dilatation of the bladder, ureters, and pelves of the kidneys. In certain instances great dilatation of the ureters may be present without a demonstrable anatomic cause.

When the anus is imperforate, a persistent cloacal duct, entering the bladder or the posterior urethra, is often present.

Congenital anomalies in the attachment or the continuity of the bowel are common in early life. Evidence of malrotation of the bowel is always sought. The mesentery of the small bowel may be abnormally long or the ascending colon may be unattached and thus permit free and wide movement of the cecum and appendix. A Meckel's diverticulum emerging from the free border of the ileum and sometimes connected by a fibrous cord with the umbilicus may be present at a point eight to forty inches above the ileo-cecal valve. Such diverticula are often lined by gastric mucosa. The adjacent mucosa of the ileum should be examined carefully in all cases for evidence of ulceration. The most frequent sites of atresia of the bowel are in the duodenum, the jejunum and the ileum. When atresia of the esophagus or a tracheo-esophageal fistula is present,

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the neck and throat organs are removed with the stomach for the more careful examination of the anomaly and the preservation of a gross specimen.

The extra-hepatic bile ducts and the gall bladder are often the seat of congenital anomalies. The common, cystic, or hepatic ducts may be absent, or present only as fibrous cords.

In the young, the adrenal glands are much larger in proportion to the size of the kidney than in the adult. During the first few weeks after birth the great bulk of the gland is composed of fetal cortex which is usually deep red in color as contrasted to the gray permanent cortex. The fetal cortex occupies the central or medullary portion of the gland. The adrenal glands of newborn infants are sometimes the seat of massive hemorrhage.

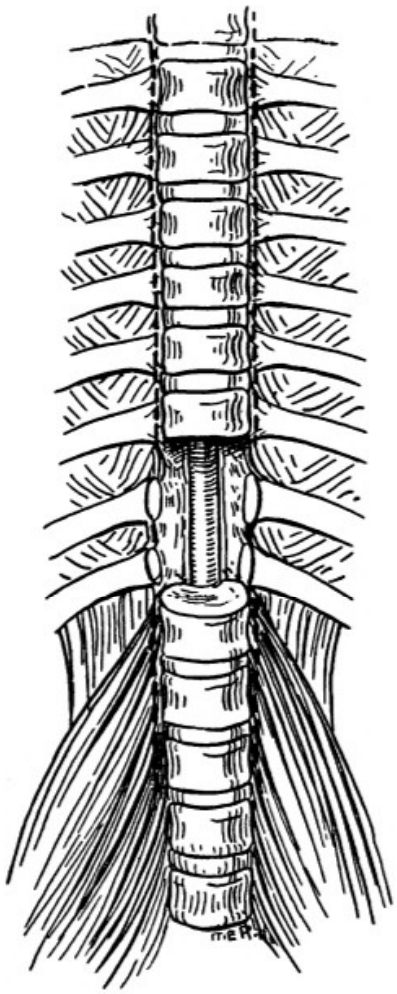

FIG. 31. Method of removing the spinal cord by the anterior approach in postmortem examinations on infants and children. The cord, still covered by dura, may be seen, since two vertebral bodies have been removed. The dotted lines indicate the paths of the knife incisions for the removal of the vertebral bodies.

The testes in young infants are often found in the inguinal canals or even in the abdomen. A careful search should be made if they are not present in the scrotum.

Particular attention is paid to the amount and distribution of fat in the subcutaneous tissues, perirenal regions, omentum and mesentery. In keratomalacia particularly, depletion of fat in the usual body depots is one of the characteristic findings at necropsy.

5. REMOVAL OF THE SPINAL CORD. After the thoracic and

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abdominal organs have been taken from the body, the spinal cord is removed by an anterior (ventral) approach. In newborn infants a sharp dissecting scalpel may be used; in older infants a strong primary incision knife is recommended. An incision is made on each side of the vertebral column at an oblique angle through the bodies into the spinal canal (Fig. 31). The vertebral bodies thus freed are removed. In older children the costotome may be used after the knife incision has been made. The cord enclosed in its dural sac is removed in the same manner as in the adult. In newborn infants special care is paid to the examination of the cervical vertebrae. Tears in the capsule of the vertebral joints in the cervical region, as a result of trauma suffered at delivery, are sometimes accompanied by massive hemorrhage into the spinal canal.

6. REMOVAL OF THE BRAIN OF THE NEW BORN. The scalp is incised and reflected as in the adult. Hematomata may be present beneath the scalp or beneath the periosteum overlying the calvarium (cephal-hematomata). Fractures are sometimes encountered in the calvarium. Measurements are taken of the anterior and posterior fontanelles. The anterior fontanelle may bulge above the level of the calvarium when increased intracranial pressure has been present.

The main problem in the examination and removal of the brain of the new born infant is the determination of the presence of birth injuries. The most widely used method for removing the brain was devised by Beneke[3] and independently described by Holland.[4] It is impossible to examine adequately the brain of a new born infant by any method other than the Beneke, or one of its modifications. After the scalp has been reflected, parallel incisions one and one-half centimeters to each side of the sagittal suture are made in the calvarium. The incisions are carried forward through the frontal bones to a point just above the orbital plates. After the leaves of the calvarium are cut away, only the narrow rim of calvarium adjoining the sagittal suture is left in place. The infratentorial basilar structures are examined by means of the removal of triangular windows from the occipital bone on each side of

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the midline just below the lateral sinuses. The cerebral hemispheres are removed one at a time. Care is taken to preserve the posterior portion of the third ventricle and the corpora quadrigemina.

FIG. 32. Modification of the Beneke technique for the removal of the brain in postmortem examinations on young infants. Paramedian incisions have been made on each side of the sagittal suture. The lamboidal suture and the coronary suture on each side have been opened and one leaf of the calvarium on each side has been turned out. The falx and tentorium are shown.

The falx and the tentoria are well demonstrated by the Beneke method. The main disadvantage lies in the difficulty of reconstructing the head and of obtaining a smooth surface above the eyes after the head has been restored.

We have found the following modification of the Beneke procedure suitable for most purposes (Fig. 32). The calvarium is opened by a scalpel or by a pair of strong thin-bladed scissors. The anterior fontanelle is pierced at two points ap-

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proximately two centimeters from the midline in the coronal suture. Placing the lower blade of the scissors in the opening, first on one side, then on the other, the operator makes an incision along the parietal suture to a point within one and one half centimeters of the sagittal suture. Inserting the lower blade of the scissors between the calvarium and the dura, he makes a paramedian incision one and one half centimeters lateral to the sagittal suture on each side as far as the posterior fontanelle. When it is not possible to strip the dura from the calvarium, the lower blade of the scissors is placed beneath the dura. The dura is then incised with the calvarium. The scissors cut, which easily severs the thin bone, is carried from the posterior fontanelle along the lambdoidal suture on each side. A similar incision is made on each side along the coronal suture. The flap of partially freed calvarium is turned back on its hinge, which may be narrowed by a cut perpendicular to each suture for a distance of one or two centimeters on each side. The flap is not completely severed from its connections with the skull. The flaps (one on each side) thus held open in petal fashion, permit free access to the brain.

If the dura has not previously been reflected, it is lifted gently by mouse-toothed forceps and cut along the line of the incision through the calvarium. The convexity of the brain may now be examined. Taking care not to injure the friable brain, the operator places the flat handle of the scalpel between the falx and the cerebral hemisphere, first on the left and then on the right, and draws the hemisphere away from the falx. The falx is inspected for evidence of tears or hemorrhage within its fibers. By lifting the occipital lobe, first on one side and then on the other, vertically upward and then drawing it medially, the operator exposes the tentorium, the great vein of Galen and its tributary veins from the pia.

A choice between two methods of removing the brain is now open to the operator. If tears in the falx or in the tentorium are present, and those structures are to be preserved as a gross specimen, or if a clear demonstration of the tears is desired for teaching purposes at autopsy, the hemispheres

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may be separated from the cerebellum, pons and medulla and removed separately. The operator draws the hemisphere to be removed from the midline by his left hand and inserts a scalpel adjacent to the falx. A single incision is then made above the pons through the cerebral peduncle. The falx and tentorium are now removed. By means of a scissors cut the falx is severed from its attachment at the crista galli. The tentorium is severed from its lateral attachments. Now the falx, connected with the tentoria, the longitudinal sinus and the attached portion of calvarium left by the parasagittal incision, is drawn backward and severed at the posterior fontanelle. A gross specimen may be prepared for permanent demonstration of the dural septa. The cerebellum, pons, medulla and cervical portion of the cord are removed after the cord has been severed transversely by means of the Chiari myelotome.

If a good view of the falx and tentorium has been obtained before the removal of the brain, the brain should be removed in one piece. After the falx has been severed at the crista galli, the tentorium on each side is freed as in the adult technique. The falx and the bridge of calvarium containing the longitudinal sinus are then drawn backward to hang over the occipital bone. By means of gentle shaking the operator frees the frontal lobes. He then inserts the fingers of his left hand beneath the frontal bones to draw back the frontal lobes. Removed in the usual manner, the brain is fixed and sectioned according to the technique used for the adult brain.

By this modification of the Beneke technique, the brain may be removed without injury and the frontal bones left undisturbed. The maintenance of the frontal bones is of great importance in the reconstruction of the head. We have used this modification of the Beneke technique with success for several years.

A brief note on the anatomy of the dural septa, as described by Holland, will clarify the problems of the examiner in the removal of the brain of the new born infant.[4] The dura mater consists of an outer and an inner layer. The inner layer forms

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an inner lining to the periosteal layer and its septa. The outer layer, which is really a periosteal layer, is a tough fibrous membrane lining the inner surface of the cranial bones. The periosteal layer projects four septa of fibrous tissue into the cranial cavity: the falx cerebri, the two leaves of the tentorium cerebelli and the falx cerebelli. These septa take origin along the course of the venous sinuses, which are formed by clefts in the inner layer of the dura. The septa meet at the confluence of the sinuses (the torcular Herophili). The falx cerebri follows the course of the superior longitudinal sinus; the tentorium cerebelli follows that of the lateral sinus; the falx cerebelli, that of the occipital sinus.

The septa are not of equal strength and thickness throughout. At definite places aggregations of fibers form the strengthening bands of Holland. These strengthening bands form two main systems: the antero-posterior and the vertical. The antero-posterior system has three parts:

1. The central portion is a wedge-shaped mass firmly adherent to the occipital bone at a point opposite the occipital protuberance and below the torcular Herophili.
2. The upper part of the system is a strong band which lies free in the lumen of the upper longitudinal sinus and then passes downward and forward in front of the torcular to join the inner mass.
3. The third or lower part, a broader but thinner collection of fibers arranged around the occipital sinus, forms the falx cerebelli.

The vertical system is composed of two opposing sets of convergent fibers. From above downward fibers descend from the falx cerebri; from below upward fibers pass from the tentorium. The converging fibers meet in a strong band, the main part of which, belonging to the tentorium, forms the curved part of the free edge of the tentorium. As the band curves downward and forward it blends with the horizontal band of the tentorium. Where the falx cerebri and the tentorium cerebelli meet they blend and form a strong band, or line, which Holland has called the *white line*.

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The most important portion of the septa, as far as birth injuries are concerned, the triangular portion of the tentorium, is bounded above by the *white line,* below by the line of the horizontal band of the tentorium and in front by the curved free edge of the tentorium. This triangle, which includes the anterior vertical band of the tentorium, is the part most commonly subjected to strain during delivery and most commonly the site of tears.

Subdural hemorrhage in the new born infant is most often caused by rupture of the small tributaries of the great vein of Galen near its junction with the straight sinus. The vein of Galen itself is more rarely torn.

7. SKELETON. Portions of several ribs which include the costochondral junction are always removed for gross and microscopic study. The lower ribs are chosen, since evidences of rickets or of scurvy are more pronounced here than in the upper ribs. Other bones of the skeleton are removed as in the examination of the adult. A portion of the mandible containing deciduous teeth is removed when possible.

8. EUSTACHIAN TUBES AND AIR SINUSES OF THE SKULL. In the infant the Eustachian tube is shorter, straighter, and relatively wider than in the adult. Because it is more constantly horizontal in position, and because of a less efficient mechanism of closure in the pharyngeal orifice, infectious material enters the middle ears more easily than in later life. At birth, the maxillary sinuses and the ethmoidal cells, and sometimes the sphenoidal sinuses, are fairly well developed. The frontal sinuses are usually not developed until after the second year.

REFERENCES

1. BLACKFAN, K. D., and WOLBACH, S. B.: Vitamin A Deficiency in Infants, J. Pediat., 3:679, 1933.
2. FARBER, SIDNEY, and WILSON, JAMES L.: Atelectasis of the New-Born, Am. J. Dis. Child., 46:572, 1933.
3. BENEKE, R.: Ueber Tentoriumzerreissungen bei der Geburt, Muench. med. Wchschr., 57:2125, 1910.
4. HOLLAND, EARDLEY: The Causation of Foetal Death. No. 7 in Series of Reports on Public Health and Medical Subjects (British). London, His Majesty's Stationery Office, 1922.

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APPENDIX A

TABLES OF AVERAGE WEIGHTS OF ORGANS

THE FOLLOWING TABLES of average weights of organs have been compiled from several sources. Acknowledgment is made in each case. The most complete and careful studies in recent years on weights and measurements have been made by Roessle* and Roulet,[1] whose book has superseded the classic *Daten und Tabellen* of Vierordt.[2] Their work should be consulted by the interested pathologist.

TABLE I

WEIGHT IN GRAMS OF THE MORE IMPORTANT ORGANS OF THE ADULT
(Compiled from Roessle and Roulet)

Organ	*Male*	*Female*
Heart	316	270
Lungs (both)	800	650
Thyroid	30	30
Brain	1350–1450	1250–1350
Liver	1500–1650	1400
Spleen	120– 150	135
Kidneys (both)	280	250
Adrenals (both)	14	12.6
Testes (both)	34–43	—
Pancreas	90	85
Pituitary	0.6–0.7	0.6–0.8
Pineal	0.16	0.15
Parotid Glands (both)	31.0	22.6
Submaxillary Glands (both)	16.9	13.9

* For permission to reproduce data from this book, the author is grateful to Professor Roessle and to the firm of Julius Springer, Berlin.

[1] Roessle, R. and Roulet, F.: Mass und Zahl in der Pathologie, Berlin, Julius Springer, 1932.

[2] Vierordt, H.: Daten und Tabellen, Jena, Gustav Fischer, 1893.

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TABLE II

AVERAGE WEIGHT IN GRAMS OF THE IMPORTANT ORGANS OF INFANTS AND CHILDREN
(Compiled from Coppoletta and Wolbach)*

Age	Body length	Heart	Lungs		Spleen	Liver	Kidneys		Brain
			Right	Left			Right	Left	
	cm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.
Birth–3 days	49	17	21	18	8	78	13	14	335
3–7 "	49	18	24	22	9	96	14	14	358
1–3 wks.	52	19	29	26	10	123	15	15	382
3–5 "	52	20	31	27	12	127	16	16	413
5–7 "	53	21	32	28	13	133	19	18	422
7–9 "	55	23	32	29	13	136	19	18	489
9–3 mos.	56	23	35	30	14	140	20	19	516
4 "	59	27	37	33	16	160	22	21	540
5 "	61	29	38	35	16	188	25	25	644
6 "	62	31	42	39	17	200	26	25	660
7 "	65	34	49	41	19	227	30	30	691
8 "	65	37	52	45	20	254	31	30	714
9 "	67	37	53	47	20	260	31	30	750
10 "	69	39	54	51	22	274	32	31	809
11 "	70	40	59	53	25	277	34	33	852
12 "	73	44	64	57	26	288	36	35	925
14 "	74	45	66	60	26	304	36	35	944
16 "	77	48	72	64	28	331	39	39	1010
18 "	78	52	72	65	30	345	40	43	1042
20 "	79	56	83	74	30	370	43	44	1050
22 "	82	56	80	75	33	380	44	44	1059
24 "	84	56	88	76	33	394	47	46	1064
3 yrs.	88	59	89	77	37	418	48	49	1141
4 "	99	73	90	85	39	516	58	56	1191
5 "	106	85	107	104	47	596	65	64	1237
6 "	109	94	121	122	58	642	68	67	1243
7 "	113	100	130	123	66	680	69	70	1263
8 "	119	110	150	140	69	736	74	75	1273
9 "	125	115	174	152	73	756	82	83	1275
10 "	130	116	177	166	85	852	92	95	1290
11 "	135	122	201	190	87	909	94	95	1320
12 "	139	124	...	...	93	936	95	96	1351

* Coppoletta, J. M. and Wolbach, S. B.: Body Length and Organ Weights of Infants and Children, Am. J. Path., 9:55, 1933.

(The authors of this paper and the Editor of the American Journal of Pathology kindly granted permission to reproduce Table II).

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TABLE III

MEAN WEIGHT OF THE PARATHYROIDS AT VARIOUS AGES IN GRAMS
(Compiled from Pappenheimer and Wilens)*

Age in years	*Right upper*	*Right lower*	*Left upper*	*Left lower*	*Combined weight (calculated)*
10–19	0.022	0.025	0.030	0.025	0.102
20–29	0.029	0.039	0.026	0.030	0.124
30–39	0.027	0.024	0.023	0.031	0.105
40–49	0.031	0.038	0.034	0.030	0.133
50–59	0.023	0.033	0.025	0.032	0.113
60–69	0.031	0.033	0.028	0.032	0.124
Over 70	0.026	0.022	0.021	0.030	0.099

* Pappenheimer, A. M., and Wilens, S. L.: Enlargement of the Parathyroid Glands in Renal Disease, Am. J. Path., 11: 73, 1935.

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TABLE IV

WEIGHT IN GRAMS OF THE UTERUS AND OF THE OVARY AT VARIOUS AGE LEVELS
(Compiled from Roessle and Roulet)

Age	*Uterus*	*Ovary*
Birth–1 month	1.87	0.255
2–12 months	1.37	0.33
1– 5 years	1.81	1.01
6–10 years	2.34	2.21
11–15 years	7.95	7.94
16–20 years	26.95	7.94
21–30 years	49.26	11.30
31–40 years	52.35	10.66
41–50 years	58.00	7.52
51–60 years	51.76	5.03
61–70 years	41.40	4.13
71–90 years	37.81	4.09

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TABLE V

MEAN WEIGHT IN GRAMS OF THYMUS AT VARIOUS AGE PERIODS*

Age	*Weight*
Stillborn (48–52 cm.)	10.6
Birth–23.9 hours	12.7
24 hours–5.9 months	19.3
1– 2.9 years	26.3
3– 4.9 years	27.7
5– 9.9 years	30.5
10–14.9 years	31.1
15–19.9 years	25.7
20–24.9 years	20.5
25–29.9 years	19.3
30–39.9 years	19.7
40–59.9 years	18.7
60–90 years	13.4

* From Growth and Development of the Child. Part II: Anatomy and Physiology, page 345, New York, The Century Company, 1933. Edited by Kenneth D. Blackfan.

(Reproduced through the kindness of Dr. K. D. Blackfan and The Century Company).

TABLE VI

WEIGHT IN GRAMS OF THE PROSTATE AT VARIOUS AGE PERIODS
(Compiled from Roessle and Roulet)

Age	*Weight*
Birth–1 month	0.56
2–12 months	0.79
1– 5 years	1.01
6–10 years	1.92
11–20 years	8.22
21–30 years	16.20
31–40 years	19.82
41–50 years	21.05
51–60 years	20.36
61–70 years	23.25

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TABLE VII

WEIGHT IN GRAMS OF BOTH SUPRARENAL GLANDS AT VARIOUS AGE PERIODS
(Compiled from Roessle and Roulet)

Age	*Male*	*Female*
Birth–1 month	6.22	5.23
2–12 months	3.35	3.15
1– 5 years	4.60	4.20
6–10 years	6.60	6.01
11–15 years	8.63	7.99
16–20 years	12.95	11.00
21–30 years	13.71	12.97
31–40 years	13.91	13.02
41–50 years	13.84	12.00
51–60 years	13.36	11.65
61–70 years	13.00	12.14
Over 70 years	12.16	11.72

TABLE VIII

WEIGHT IN GRAMS OF THE RIGHT AND OF THE LEFT LUNG
(Compiled from Roessle and Roulet)

Age in Years	*Right Lung*		*Left Lung*	
	Male	*Female*	*Male*	*Female*
12	201.00	173.50	203.33	160.00
13	322.00	243.33	.....	248.00
15–20	379.00	322.75	291.00	297.66
21–30	421.75	346.20	354.28	287.09
31–40	435.07	336.40	377.71	286.40
41–50	429.23	387.15	363.20	319.30
51–60	445.90	340.60	374.80	291.60
61–70	410.92	361.60	378.53	265.90

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APPENDIX B

COPY OF THE REPORT OF THE NEW YORK COMMITTEE ON RULES GOVERNING PATHOLOGISTS AND UNDERTAKERS

A COPY of the report on the necropsies prepared by the Joint Committee representing the New York Academy of Medicine, the New York Pathological Society and the Metropolitan Funeral Directors' Association, under the chairmanship of Dr. George Baehr,* is appended below. It is taken from the account given in the *Archives of Pathology*, November 1932, vol. 14, p. 701. The report of the New York Committee is included here in the hope that it may serve as a guide for similar committees in other cities of the United States.

"A. DESIRABILITY OF NECROPSY

1. All agree that postmorten examination by a pathologist is desirable; first, to provide reliable recorded information concerning the cause of death and the nature of the various disease processes; second, to confirm or amend the opinions formed by the physicians during the life of the patient, so that they may serve the next patient with greater confidence and skill; third, to reveal to the physicians continually the physical changes in the interior of the body which are associated with disordered behavior during life; fourth, to provide for the advance of human knowledge concerning the nature of disease in general. It is well recognized that the practice of postmortem examination in a hospital exercises a constant influence to improve the service and to correct serious deficiencies, as well as to improve diagnosis and prevent disease.

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* The author is grateful to Dr. Baehr and to the Editor of the *Archives of Pathology* for permission to reprint this report.

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B. Coöperation of Hospital Authorities and Funeral Directors

1. The hospital and its medical staff have not completed their service to the family on the death of a patient. They owe to the family a further service, namely, to give an account of what has occurred, together with the most accurate possible explanation. This requires that some representative member of the family come to the hospital for a personal interview and give permission for the examination of the body of the deceased. The funeral director must recognize this relationship and should not oppose the proper efforts of the hospital authorities and the physicians in the discharge of this obligation.

2. The funeral director is particularly interested in getting into his own hands: (1) the death certificate, (2) the permit to remove the body and (3) the body itself, so that he may prepare it in a satisfactory manner for the funeral ceremony. He must feel certain that nothing will arise to interfere with his plan and program. Unforeseen delay may require cancellation of contracts for transportation and various other services, thus increasing the expense and causing dissatisfaction. Unreasonable delay by the hospital, in its attempt to obtain permission for necropsy, is therefore objectionable to the funeral director. The conflict of interests in this connection requires mutual consideration and a spirit of coöperation on the part of all concerned. Disputes of this nature should therefore be adjudicated by a permanent joint committee on coöperation.

3. The funeral director or his agent must present to the hospital acceptable evidence that he has been authorized by the family to take charge of the body. The blank form employed for this purpose should conform with the requirements of the department of health.

4. Hospital employees, in general, must not give information to favored funeral directors or to any other unauthorized persons in regard to persons critically ill or dead in the hospital. It is proper for the chief administrative officer of the hospital, when requested by the family, to refer the selection of a funeral director to the office of the local Funeral Directors' Association

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or quite properly, to select one by rotation from an approved list in his own office. Such a selection must never be left to a minor employee of the hospital. Proof that a minor employee has offered recommendations of this sort should be followed by his instant dismissal from the service.

5. The hospital authorities should make certain that the necessary data for a death certificate, except those facts relating to the nature, progress and termination of the present illness, are entered on the record at the time of admission of the patient. Such data as date of birth and the maiden name of the mother may be obtainable only with great difficulty after death of the patient. The death certificate may be filled out by a clerk using a typewriter, leaving only the diagnosis and signature to be supplied by the physician who completes the certificate.

6. Report of a death to the medical examiner should be made in those circumstances where this is legally required, and the decision to notify this official should be made at the time of death of the patient, entirely without regard to the attitude of the relatives concerning necropsy. It is improper for any member of the hospital staff to threaten to call the medical examiner if permission for necropsy is refused. Any such procedure of threatening or browbeating may be regarded as evidence of lack of ability to handle the situation.

7. In general, the permission for necropsy should be asked for soon after the death has occurred. Often it is best to make the request at once whenever the proper relative of the deceased is present in the hospital. Reasonable consideration should be accorded to every one concerned in determining when the matter has been adequately presented and the final decision reached.

8. Arrangements should be worked out in every hospital whereby the unnecessary loss of time on the part of the funeral director may be obviated, and the funeral director should be instructed that he will be promptly informed by telephone when the death certificate is signed and the body is ready for him.

The telephoned information in regard to the dead, particularly before a funeral director is known to have been engaged, should be given only by an executive officer of the hospital and

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should be carefully guarded unless the persons on the wire are personally known.

9. Interference by a funeral director with the legitimate efforts of the hospital to obtain permission for autopsy shall be regarded as a reportable grievance.

C. Technic of the Necropsy

1. In males, the incision is to extend from the suprasternal notch to the pubes in the midline, passing to the left of the umbilicus. In no circumstances shall the incision in males be extended further upward.

2. In females and in sailors who are to be buried in uniforms, the V-shaped incision is to be used, that is, an incision extending from the acromial end of the clavicle to the xiphoid and up to the acromial end of the corresponding clavicle. The flap thus outlined must be dissected upward close to the deeper structures, and every effort must be made to prevent perforation of the skin in the process of dissection.

3. At least from one-half to 1 inch (1.2 to 2.5 cm.) of the external carotid arteries is to be left free and ligated. The internal carotids and the vertebrals are to be ligated, and at least from one-half to 1 inch of the iliacs is to be left intact and ligated.

4. The scalp is to be divided by an incision behind the ear, extending from one mastoid process to the other, as indicated in Figures 2 and 3. The incision is to pass over the vertex when the hair is abundant, or somewhat posterior to this line when it is sparse. In women, the hair is to be parted along the projected line of incision to avoid cutting it. For the same reason, after the initial incision has been made, the knife should be carried in such manner that its sharp edge faces the dissector. Care should be taken not to tear or otherwise injure the scalp. The scalp is reflected backward and forward, so that the calvarium is exposed anteriorly slightly above the frontal eminences and posteriorly somewhat behind the occipital protuberance.

Before the skull is sawed, the line through which the saw is

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to be carried is to be mapped out with the aid of a sharp instrument (Fig. 4). The temporal muscles are to be cut on a plane parallel with the projected line (Fig. 4) to preserve stumps on either side long enough to provide for suturing and immobilization of the replaced calvarium.

5. The removal of the skull cap is to be planned and carried out in such a manner as to insure its secure approximation. This is best accomplished by sawing in two intersecting lines which meet at an obtuse angle behind the ear (Fig. 3), the anterior incision commencing at the level of the hair line.

6. Before closing the cranial cavity, every effort should be made to provide against leakage. This is best carried out by the following procedures: (a) by ligating the carotid and vertebral arteries, (b) by plugging the foramen magnum tightly with cotton and (c) by filling the cranial cavity with oakum.

7. In suturing the skin a moderately small needle should be used so as to avoid leakage and disfigurement.

8. After the autopsy is completed, the body is to be delivered to the embalmer in a thoroughly clean condition—the skin washed, all cavities thoroughly sponged and dried and no source of leakage allowed to remain.

9. After the completion of the autopsy, the embalmer is to be allowed the use of the autopsy room for the preparation of the body for burial, provided that this does not conflict with the immediate use of the room for another autopsy and provided also that the embalmers leave no cleaning to be done by the hospital employees."

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APPENDIX C

A PROTOCOL BY VIRCHOW

FOR THE INTEREST of the student, a copy of a protocol by Virchow (T. P. Smith translation) is appended here. Virchow included this among other protocols in his book on autopsy technique.*

"CASE I

A man unknown. Dead when brought in; face covered with blood; left side of face, particularly about the ear, of a bluish-red color. Death from suffocation caused by pulmonary hemorrhage and edema.

Length of time occupied in the examination two hours and five minutes. November 1875.

A. EXTERNAL EXAMINATION

1. The body is that of a man apparently from forty to fifty years of age; height 1.75 metre (68.89 inches); very strongly built; adipose tissue slight in quality; muscles greatly developed—those of the arm and thigh less so in proportion than those of the forearm and leg.

2. Body generally pale in color; abdomen slightly green, flanks posteriorly, scrotum and glans of a uniform bluish-red; dorsum the same, and pale only where exposed to pressure; on pressing with the finger this bluish-red color can be made to disappear, not easily, though tolerably completely. On an incision being made, only distended vessels are visible in the skin and subcutaneous tissues, from which fluid blood escapes.

3. The body being turned over for the purpose of this examination, a thin, sanguineous fluid escapes from the nose and mouth.

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* Virchow, R.: Postmortem Examinations: Translated from the Fourth German Edition by T. P. Smith, Philadelphia, P. Blakiston's Son & Co., 1895.

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4. The face, particularly the left side as far as the ear, and the beard are much soiled with dried blood, the largest quantity being on the nostrils and lips. A brownish-red, dry, powdery substance, on the left side converted into larger coherent crusts of dried blood, covers the neck and upper part of the chest.

5. Hair of head abundant, curly, light brown in color; numerous scattered gray hairs. The beard full, especially about the chin; whiskers strongly developed, color more reddish-brown; eyebrows thick, and, like the eyelashes, of a dark grayish-brown color; pupil pale grayish-blue; face large; forehead prominent; nose large and straight; high cheek bones; front teeth perfect; molar teeth more or less carious and defective; no traces of recent injury; lips pale and thin.

6. The body presents no other particular characteristics, only that the prepuce is unusually short, and covers no more than the edge of the glans; there is, however, no cicatrix of any kind to be seen.

7. The hands large; the nails long and bluish, the projecting edges filled up with thick black dirt, traces of which are seen also in the palms of the hands.

8. There is some amount of mobility in the principal joints of the extremities, but there are signs of rigor mortis in all the smaller articulations.

9. The eyelids are only partially closed; the corneae transparent, and comparatively tense.

10. No foreign body about the nostrils, with the exception of the blood already mentioned.

11. The lips, as well as the teeth, are slightly parted; the tongue is behind the teeth, and, like the palate, covered with fluid blood.

12. External parts of ears unusually large; the left ear of a dark brown-red color. On an incision being made, blood flows everywhere copiously from the divided vessels, but there is no sign of extravasated blood in the tissue; auditory meatus empty.

13. Neck not very easily movable; no change perceptible.

14. Chest full; abdomen slightly distended.

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15. Cutis anserina slightly marked on the extremities, especially on the lower ones; the legs above the ankles rather large, pitting on pressure; the tissues on section found to be infiltrated with fluid. Just above the ankles there is a loose knotted piece of cord, twisted round each of them; corresponding to this there is a transverse indentation on the inner and anterior aspects. This, when cut into, exhibits no extravasation of blood.

16. The parts about the anus much soiled with brown excrement; the anus closed.

17. In conclusion, there is no perceptible mark of external injuries.

B. Internal Examination

1. The cranial cavities

18. The soft parts covering the skull are divided, as directed, by an incision carried transversely over the head, and reflected back. All these parts are then seen to be somewhat red in color, the alteration being more marked posteriorly than in front—the redness, however, not being sufficiently distinct on any one spot for it to indicate extravasation; on the other hand, thick blood exudes everywhere from the divided vessels, and the soft parts appear to be uniformly infiltrated with reddish serum.

19. The skull cap, very broad and much arched, exhibits posteriorly a similar reddish infiltration of its tissue, especially at the sutures, which are deeply indented, and furnished in various places with ossa triquetra. The color of the remaining portions of the skull cap is a dirty yellowish-gray, somewhat more whitish in isolated spots.

20. The skull cap is sawn through with difficulty, and when divided, cannot be taken off from the tough dura mater. The latter is therefore immediately cut through. On attempting to detach the bone and dura mater, the brain also follows, and this latter has to be removed by separating methodically its connections in the base of the skull.

21. The brain being removed, there is no appearance of serum nor of any other effusion on the basis cranii. The large

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sinuses in that situation contain only a moderate amount of fluid blood.

22. There is some difficulty in separating the tough dura mater from the base of the skull and the posterior portions. There is no sign of any kind of injury to the bones of the base.

23. There is no change, also, on the base of the brain itself. The great arteries are large, but flat and empty. The pia mater everywhere fine and soft, and its veins only filled with blood near their origin.

24. After the removal of the brain from the roof of the skull, the inner surface of the dura mater is found to be everywhere of a pale color. There is no deposit connected with it; it is somewhat thick and tendinous; the longitudinal sinus large, but filled throughout with fluid blood.

25. The dura mater is then removed from the roof of the skull. Its external surface is also pale; the blood vessels very prominent, but empty.

26. Neither fissure nor injury of any kind visible in the roof of the skull; diploë scanty in amount. The bones, on an average, are from five to six millimeters thick. Fine, red, very vascular, soft growths on the inner surface of the frontal bone in the middle line.

27. The surface of the brain well formed; the pia mater delicate throughout; the veins filled with blood, tumid even to roundness on the left side, somewhat less so upon the right.

28. On cutting into them, the lateral ventricles are found to contain a small, inappreciable quantity of clear fluid. Cavities of normal size; posterior cornua obliterated. Septum soft, and easily torn; choroid plexus and vessels of the velum of a dark-red color, owing to great distention. The vessels separable only with difficulty from the corpora quadrigemina.

29. On cutting into the hemispheres of the brain the tissue is found to be moist and glistening; the white substance exhibits numerous bloody points, from which drops of blood exude on pressure; these drops can be washed away with water. The gray substance of the cortex pale reddish; that of the corpus

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striatum and of the thalamus similar in appearance, and also moist. No other change. Consistence of the brain good.

30. Corpora quadrigemina pale. Pineal gland small and red.

31. The fourth ventricle empty; its surface pale and soft, its choroid plexuses reddened.

32. The cortex of the cerebellum reddened throughout, though the vessels are not perceptible; the medullary substance, on the contrary, traversed by congested venous branches. Consistence good; moisture moderate in quantity. No change.

33. At the base of the brain, all the lobes cut through by numerous parallel transverse incisions; no alteration of any kind apparent. The gray substance slightly reddened throughout.

34. The gray substance of the pons Varolii and the cerebral peduncles of a reddish color; the white substance traversed by numerous congested veins. Consistence good.

35. The medulla oblongata pale; the gray matter of the rhomboid fossa somewhat more reddened.

II. THORAX AND ABDOMEN

36. A long incision is made from the chin to the pubic symphysis as directed, the integuments divided, and the cavity of the abdomen laid open. Adipose tissue slightly developed; muscles somewhat pale.

37. No foreign body in the abdominal cavity. Position of the parts normal. Cecum, transverse colon, and the ascending portion of the large intestines are much distended; also a portion of the small intestine—in part with gas, and in part, apparently, with fluid. All these parts are pale in color; the omentum only presents a few distended veins.

38. The arch of the diaphragm on each side is between the fourth and fifth ribs.

(*a*) *The Thorax*

39. After removal of the sternum the lungs come into view, somewhat distended, particularly the left one; position of the

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parts normal in other respects. The pericardium to a great extent covered by the lungs.

40. On the left side several very firm adhesions between the surface of the lung and the wall of the thorax. A tablespoonful of thin reddish fluid in the most posterior part of the pleural cavity.

41. On the right side the adhesions to the upper lobe are somewhat more extensive, but equally firm, and traversed by vessels. A smaller amount of fluid than on the left side. Internally, near the pericardium, the adhesions are still more extensive.

42. The pericardium contains a tablespoonful of a slightly reddish but clear fluid.

43. The heart about the size of a man's fist, its right surface flattened, a slight amount of tendinous deposit (Sehnenflecke, maculae albidae), the right ventricle moderately covered with fat, pale, and only the coronary veins somewhat distended with blood. The right auricle contains particularly fluid blood, mixed with a very small quantity of soft, friable, buffy clot. The quantity of blood collected from the right side of the heart and the large veins amounts to 150 cubic centimetres. The right ventricle contains fluid blood only, inappreciable in quantity. The left auricle contains fluid blood and a small quantity of thick blood. The left ventricle quite empty. The blood everywhere equally dark. The aorta three centimetres in diameter, its walls thick, inner coat especially thickened. The pulmonary artery about the same size, but with thin walls. The valves at the mouths of both vessels close. On section, right ventricle found to be dilated, left ventricle large. Muscular tissue somewhat dark; a little paler on the right side. Valves without alteration, but of a deep-red color.

44. The large veins of the neck moderately distended with fluid blood; arteries empty. The large nerves apparently unaltered.

45. The cavity of the mouth opened, as directed, from beneath; the tongue drawn away, and the upper part of the throat exposed. All these parts covered with a layer of bloody

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mucus, which, however, can be easily rubbed off; after its removal the mucous membrane appears slightly reddened, but otherwise unchanged. Lingual follicles large, whitish. Tonsils slightly swollen.

46. A considerable quantity of bloody froth with large bubbles in the larynx and upper portion of the air tubes. This removed, the mucous membrane appears only slightly reddened; on the posterior aspect of the tubes the vessels of the mucous membrane distended with blood, but no other change.

47. The remaining thoracic viscera, with the lungs, are now removed, together with the costal pleura.

48. Lower portion of the esophagus is covered with reddish fluid, which can be easily taken off. After its removal, no alteration visible in the subjacent mucous membrane.

49. There is slight dilatation, and thickening of the internal coat, of the thoracic portion of the aorta, but no breach of surface. The same may be said of the large branches of the artery going to the neck.

50. The upper part of the air tubes, as well as their large ramifications, are filled with frothy and bloody matter.

51. The lungs seem large, very concave on their diaphragmatic surface, studded over, especially on the right side, with smooth projections of their tissue greatly dilated (emphysematous). The lungs, in general, are gray in color, pale anteriorly, reddened posteriorly. Numerous furrows, due to absorption, on the anterior surface. These latter places feel harder to the touch; the rest of the tissue is soft, but only slightly crepitant.

52. On section, in the apex of the right lung is found a ramified cavity of irregular shape, about six centimetres and a half in diameter, consisting of two compartments, separated by a thin septum, and each of them four centimetres and a half in horizontal diameter. Each contains a bloody, slightly frothy liquid, which can be easily removed by water. The walls of both these cavities are irregular and rough, and, on water being poured upon them, they are seen to be covered with adhesions, which readily float. Many large eroded vessels, some of them

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lying free like rafters, are found in these cavities, into which branches of the air tubes may be directly traced. In other parts of the lung there are single smaller cavities with smoother walls, and also separate circumscribed spots, externally hard to the touch, some of which appear, on section, dense, dull, grayish-red, and finely granular; others dry, grayish-white, and caseous. The rest of the pulmonary tissue is full of frothy, whitish fluid, which can be easily pressed out.

53. On the left side, below the apex, more toward the centre of the upper lobe, there are several similar cavities, varying in size from that of a walnut to a hen's egg, containing also fluid, slightly frothy blood, and connected with the air passages. The wall of these cavities is irregular and ragged; the remains of the large vessels appear as whitish projections. There is a similar cavity about as large as a walnut in the upper part of the lower lobe. Throughout the remainder of the lung there are numerous nodules of varying size—some as large as peas; a few with cavities in their interior; others solid and caseous; others, again, solid and dark gray.

(b) The Abdomen

54. Spleen closely adherent to the diaphragm and omentum; fourteen centimetres long, nine centimetres broad, three centimetres and a half thick; externally, gray steel-colored. On section, dark brown-red; pulp abundant, with numerous dark-red spots; follicles slightly enlarged.

55. Left kidney thirteen centimetres long, six centimetres and a half broad, three centimetres and a half thick. Capsule slightly dull, thin. Surface of the kidney smooth, brownish-red, bright; consistence firm. On section, the medullary and cortical substance very red, not dull; no other change. Malpighian corpuscles bloodless. Supra-renal capsule with a small amount of cortical and medullary substance; the tissue connecting it with the kidney firm and well supplied with blood.

56. On separating the parts surrounding the right kidney a fibrous adhesion between the large intestine and the under surface of the right lobe of the liver brought into view.

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57. Right kidney of same size as left, and resembling it in other particulars. Supra-renal capsule in a similar condition.

58. Bladder contracted, and containing only a few drops of whitish urine. No change in mucous membrane.

59. Left testicle somewhat mis-shapen, in consequence of fibrous adhesions on its surface. An offset from the right one at the upper part of the epididymis.

60. The stomach distended, and containing a large quantity (about 200 cubic centimetres) of thick, clotted, bloody fluid, mingled to some extent with large air bubbles.

61. Fluid of a similar kind in the commencement of the duodenum, but extending only as far as the opening of the gall duct. After this the contents are of a pale-yellowish color. Opening of gall duct normal.

62. The mucous membrane of the stomach tinged throughout with blood, but without any lesion; only the large veins distended with blood.

63. In the upper part of the intestine a large amount of a gray fluid resembling gruel, slightly colored with bile. This becomes thinner and more scanty in the upper part of the jejunum. The ileum contains a very large quantity of fluid of a brownish color. This part of the bowel is so soft that it tears when cut into with the scissors. The lowest part of the ileum contains a quantity of very fluid feces. The large intestine from the ileo-cecal valve full of thick, pulpy feces. The mucous membrane throughout the ileum thin and pale; the glands slightly tumid. In the jejunum the mucous membrane is thicker. Here and there a single gland appears tumid, but in other respects normal. In the upper part of the jejunum the mucous membrane has a whitish appearance.

64. The liver (twenty-eight centimetres broad, twenty-three centimetres from front to back, and eight centimetres thick) is firm to the touch, its surface of a pale-brownish color, somewhat firm under the knife; breaks with difficulty, and appears on section uniformly red. The lobules are large, and their color uniform.

65. The inferior vena cava contains fluid blood.

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This case is a remarkable instance of ulcerous consumption of the lung, occurring in a man in other respects vigorously developed, and in whom the disease, though obviously of long standing, had confined itself to the lungs. Owing to the advanced stage of the disease, it cannot be ascertained whether the morbid process primarily originated in bronchiectasis or caseous pneumonia; at any rate, caseous pneumonia finally supervened. It is a matter of great interest that, notwithstanding the amount of hemorrhage from the lung, the fatal result was not due simply to loss of blood (anaemia) nor to simple occlusion of the air passages by the extravasated blood, but really to the supervention of edema—a complication which is explained, on the one hand, by the robust condition of the patient; and, on the other, by the slow course of the hemorrhage. Not a single ruptured blood vessel could be discovered.

The conclusions to be drawn from the foregoing statement are as follows:

1. That death occurred from suffocation caused by pulmonary hemorrhage and edema.

2. That no signs of any external injury were revealed by the autopsy."

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